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BERYLLIUM OXIDE REFRACTORIES, II*

By H. E. White, R. M. Shremp, and C. B. Sawyer

Abstract

A description is given of the method used to extract beryllia, and some of the properties of the oxide are reviewed, including electrical and thermal conductivity.

I. Introduction

Beryllium oxide has become generally available only during the last ten years; in fact, the highly purified form has been available only within the last seven years. Since 1930, however, processes have been perfected for producing the purified oxide on a large scale with a consequent decrease in cost. The result has been an increase in the annual demand from a few ounces to as much as a ton. The present price for fluffy, calcined oxide (99.8% BeO) and for pressed brick ranges from $4.00 to $8.00 per pound, depending on the quantity, but a lower cost may be expected as production increases.

II. Raw Materials

More than twenty minerals containing beryllium are known but most of them are rare. The most important are beryl ($3BeO \cdot Al_2O_3 \cdot 6SiO_2$), phenacite ($2BeO \cdot SiO_2$), and chrysoberyl ($BeO \cdot Al_2O_3$), of which the first is the most abundant and in fact is the only one of commercial importance. The beryllium aluminate, chrysoberyl, which can be obtained directly from the ore, however, has interesting possibilities because of its high melting temperature (about 1880°C.).

Workable deposits of beryl, which usually occur as an accessory mineral in granitic rocks, are found in Massachusetts, New Hampshire, the Black Hills of South Dakota, Colorado, the Canadian Rockies, South America, France, South Africa, Madagascar, Scandinavia, and India. More than half of the beryl now used in the United States comes from India and South America.[1]

The melting point of beryl, which is about 1600°C., is greatly influenced by the presence of alkali metals as oxides.

III. Methods of Extraction

Powdered beryl is unattacked by acids except hydrofluoric acid. This acid was used as a leaching agent in early methods of extraction. Fluxing with alkali has also been employed. The process in use today,[2] however, is based on the fact that, after suitable heat-treatment, beryl reacts with sulfuric acid. The speed of reaction, moreover, increases with increasing temperature of heat treatment so that the ore becomes very reactive if it is melted and quenched by pouring into water. The quenched beryl is no longer optically active nor does it give the X-ray pattern of a crystal, indicating that the original lattice structure has been destroyed. When beryl, containing about 12% BeO, is heated to its sintering point (about 1450°C.), it yields 91% of its beryllia on treatment with 56% sulfuric acid at 250°C. The sulfate liquor thus obtained is concentrated, and beryllium sulfate is recovered by fractional crystallization. The purified sulfate is then roasted to oxide. Sulfates of aluminum, lithium, caesium, and rubidium are obtained as by-products.

IV. Methods of Analysis

Beryllium is usually determined by the hydroxyquinoline method.[3] Although this method of analysis is a great improvement over the bicarbonate separation previously used, it is tedious and difficult, and accurate results are obtained only by a skilled analyst. A rapid volumetric method is greatly desired.

V. Properties of the Oxide

(1) Melting Point

The melting point has not been accurately determined. Singer[4] gives 2450°C., whereas Ruff[5] reported 2525°C., which was later corrected to 2585°C. by Wartenberg and Werth,[6] who found 2570°C. in their determination.

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* Presented at the Fortieth Annual Meeting, American Ceramic Society, New Orleans, La., March 31, 1938 (Refractories Division). Revised copy received January 15, 1940.

For Part I, see *Jour. Amer. Ceram. Soc.*, 22 [6] 185–89 (1939). Footnotes 12, 16, and 17 have been added in this paper to the author's original Bibliography (*ibid.*, pp. 188–89).

[1] (*a*) D. W. Luks, "Beryl and Ceramics," *Foote Prints*, 10, 1–11 (1937); *Ceram. Abs.*, 16 [9] 285 (1937).

(*b*) A. B. Searle, Refractory Materials, p. 194. Charles Griffin & Co., Philadelphia, Pa., 1924.

[2] (*a*) C. B. Sawyer and B. R. F. Kjellgren, "Newer Developments in Be," *Ind. Eng. Chem.*, 30 [5] 501–505 (1938); *Ceram. Abs.*, 17 [8] 289 (1938).

(*b*) B. R. F. Kjellgren and C. B. Sawyer, "Recovery of Be from Siliceous Ores," U. S. Pat. reissue, Aug. 25, 1936; *Ceram. Abs.*, 16 [11] 359 (1937).

[3] H. B. Knowles, "Use of 8-Hydroxyquinoline in Determinations of Al, Be, and Mg," *Jour. Research Nat. Bur. Stand.*, 15 [1] 87–96 (1935); R.P. 814; *Ceram. Abs.*, 14 [11] 294 (1935).

[4] Felix Singer, "Refractory Minerals and Materials; Beryllium Oxide," *Refrac. Jour.*, 11 [11] 567 (1935); *Ceram. Abs.*, 15 [6] 182 (1936).

[5] O. Ruff, "Work in Territory of Higher Temperatures: I, Melting and Vaporization of Refractory Oxides in Electric Vacuum Furnace," *Z. anorg. allgem. Chem.*, 82, 377 (1913).

[6] H. v. Wartenberg and H. Werth, "Melting Diagrams of Refractory Oxides, II," *ibid.*, 190 [1] 178–84 (1930); *Ceram. Abs.*, 9 [11] 941 (1930).

(2) Specific Heat

The specific heat as taken from two different handbooks is given in Table I.

TABLE I

MEAN SPECIFIC HEAT OF BeO IN CAL. PER GRAM

	Mean specific heat from 0° to t°	
t°C.	I.C.T.	Gmelin
100	0.299	0.281
200	.351	
400	.421	.353
600	.461	.384
800	.487	.406
900	.497	.418

(3) Heat of Formation

Neumann, Kroger, and Kunz[7] give 145.3 kg. cal. per gram; Kroll[8] gives 135.9, and the International Critical Tables[9] give 141.2.

(4) Electrical Conductivity

Beryllium oxide is an excellent electrical insulator even at temperatures above 2000°C. Navias[10] states that the order of decreasing electrical conductivity near 212.5°C. is ZrO_2, ThO_2, MgO, Al_2O_3, and BeO. The results of a determination by Spanner[11] are given in Fig. 1, where they are compared with data reported by Backhaus.[12] Because it was necessary to transpose Spanner's table and because the experimental method and nature of his material are unknown, his curve for magnesia is also included to show the relative resistivity of the two oxides.

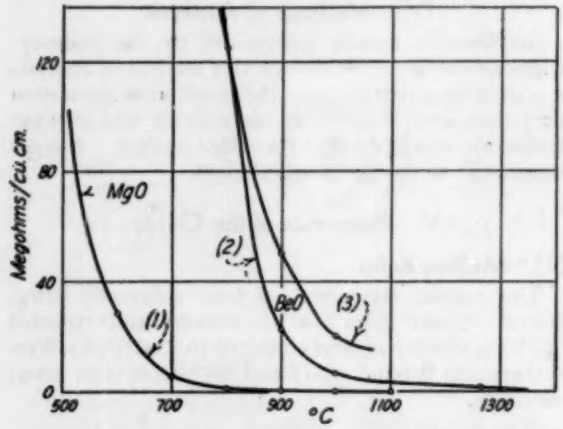

FIG. 1.—Electrical resistivity of crystalline BeO and MgO. Curve (1), data from Spanner, footnote 11; curve (3), data from Backhaus, footnote 12.

(5) Thermal Conductivity

Singer states that beryllia is an excellent conductor of heat, a fact which the present authors have confirmed by measurements on beryllia brick built into a kiln door along with brick of different compositions. The temperature drop through the several brick when the kiln temperature was 2500°F. is shown in Table II, which also gives the porosity of each type of brick. The reliability of this method leaves much to be desired, and the test suffers because of a wide variation of porosity among the samples, but the results suffice to show that the thermal conductivity of beryllia is relatively high and approaches that of silicon carbide.

TABLE II

RELATIVE THERMAL CONDUCTIVITY OF DIFFERENT REFRACTORY BRICK AS INDICATED BY TEMPERATURE DROP THROUGH EACH BRICK

Material	Temp. drop (°F./in.)	Porosity (%)	Bulk density
Silicon carbide	100	19.2	2.37
Beryllia	118	39.6	1.63
Zircon	133	19.9	3.29
Electrically fused magnesia	144	27.3	2.70
Electrically fused alumina	147	28.9	2.63
Converted kyanite (mullite)	149	27.6	2.60
Silica	151	28.4	1.76
Pa. firebrick	161	18.4	1.98

(6) Miscellaneous Properties

Beryllia is stable up to ts melting point and shows no sign of vaporization or reduct on.[19] It has a hardness[13] of 9, it is more resistant to acids, and it is a weaker base than magnesia,[1(b)] being fluxed by relatively small concentrations of calcium oxide or of alkali oxides or fluorides. On the other hand, a German company[14] cla ms that slip-cast beryllia ware is gas-tight at 2200°C., it resists molten alkalis, it is not fluxed by zirconia at 1900°C., and it does not react with carbon, carbon monoxide, or hydrogen. It is, however, attacked by acids and is fluxed by alumina and magnesia.[15]

Pure platinum melted in vacuo in a beryllia crucible is contaminated by beryllium, but it does not seem so to react when melted in air.

Beryllia[16] ware seems to have a high resistance to thermal shock.

[7] B. Neumann, C. Kroger, and H. Kunz, "Heat of Formation of Nitrides: V, Heat of Combustion of Certain Metals and Metal Nitrides," *Z. anorg. allgem. Chem.*, **218**, 379–401 (1934); p. 391.

[8] W. Kroll, "Reducibility of Alkali Earth Oxides, Particularly Beryllium," *ibid.*, **219**, 301–304 (1934).

[9] International Critical Tables, Vol. 5, p. 195 (1929).

[10] Louis Navias, "Extrusion of Refractory Oxide Insulators for Vacuum Tubes," *Jour. Amer. Ceram. Soc.*, **15** [4] 234–51 (1932); p. 248.

[11] H. J. Spanner, "Thermal Emission of Electrically Charged Particles," *Ann. Phys.*, **75**, 609–33 (1924); p. 619.

[12] K. Backhaus, "Electrical Conductivity of Base Materials, Bonding Agents, and Mixtures for Insulating Bodies for Electrical Heating Elements," *Ber. deut. keram. Ges.*, **19** [11] 461–69 (1938); for abstract from *Elektrowärme*, see *Ceram. Abs.*, **18** [2] 60 (1939).

[13] Gmelin, "Beryllium" (System No. 26), Handbuch der Anorganische Chemie, Vol. 8, pp. 82–91. Verlag Chemie, G.m.b.H., Berlin, 1930.

[14] "Degussa Geräte aus Reinen Oxyden," Deutsche Gold- und Silber-Scheideanstalt vorm. Roessler.

[15] W. H. Swanger and F. R. Caldwell, "Special Refractories for Use at High Temperatures," *Bur. Stand. Jour. Research*, **6** [6] 1131–43 (1931); R.P. 327; *Ceram. Abs.*, **10** [10] 704 (1931).

[16] J. G. Thompson and M. W. Mallett, "Preparation of Crucibles from Special Refractories by Slip Casting," *Jour. Research Nat. Bur. Stand.*, **23** [2] 319–27 (1939); R.P. 1326; *Ceram. Abs.*, **18** [11] 300 (1939).

The long crystalline range of beryllium oxide, previously attributed to the presence of small amounts of caesium oxide, has been disproved by Sawyer, who examined the beryllia spectroscopically and found no caesium oxide.

VI. Phase Equilibrium in Binary Systems

Binary systems in which BeO is one component have been investigated with results which have not always been in agreement; in fact, in some cases, there has been a great deal of controversy. The general form of the phase diagram, however, is now reasonably clear for a number of systems which have been summarized by Hall and Insley.[17]

Of special interest is the diagram for the system, $BeO–Al_2O_3$, which gives no indication of the existence of the compound $BeO·Al_2O_3$ (chrysoberyl). Wartenberg and Reusch,[18] who investigated this system, concluded that this compound melts incongruently.

[17] F. P. Hall and Herbert Insley, "Supplement to 'A Compilation of Phase-Rule Diagrams of Interest to the Ceramist and Silicate Technologist,' " *Jour. Amer. Ceram. Soc.*, **21** [4] 113–64 (1938); see Figs. 320, 321, and 322.

[18] H. v. Wartenberg and H. J. Reusch, "Melting Diagrams of Refractory Oxides: IV, Aluminum Oxide," *Z. anorg. allgem. Chem.*, **207** [1] 1–20 (1932); p. 19; *Ceram. Abs.*, **11** [11] 575 (1932).

VII. Uses

Beryllia has been used for some time as a coating for filaments in lamps, for electrodes in electron tubes, and as a cathode heating element in radio tubes. It may also be used in electrical unit heaters in which the resistance wire is imbedded in the refractory and as a lining in coreless induction furnaces. Because it is much more resistant to thermal shock and less reactive with graphite than magnesia,[19] it is particularly useful as a radiation shield around a graphite crucible.

Additional References

1. M. A. Portnav and Ya. E. Seferovich, "Beryllium Chloride," Russ. Pat. 47,684, July 31, 1936; *Ceram. Abs.*, **18** [8] 215 (1939).
2. Seri Holding Soc. Anon., "Cyclic Production of Beryllium Oxide," Fr. Pat. 833,418, Oct. 21, 1938; *Ceram. Abs.*, **18** [8] 215 (1939).
3. Gustav Jaeger and Albert Wille (Deutsche Gold- und Silber-Scheideanstalt vorm. Roessler), "Decomposing Beryllium Minerals, Particularly Beryl," U. S. Pat. 2,160,547, May 30, 1939; *Ceram. Abs.*, **18** [8] 215 (1939).

The Brush Beryllium Company
3714 Chester Avenue
Cleveland, Ohio

[19] J. Chipman, personal communication.

PROPERTIES OF CLAY CASTING SLIPS *

By George A. Loomis

Abstract

Nine casting slips were prepared, using bodies of the sanitary porcelain type. The electrolyte was a combination of 60% "N" brand sodium silicate and 40% sodium carbonate. Its amount was adjusted in each body slip to produce a cast having the right characteristics according to the "feel" test; the specific gravity of each slip was constant. The grain-size distribution of each slip was determined as well as the casting rate, consistency, and pH when the casting slips were first prepared and again after 24-, 48-, and 96-hour aging periods.

There is a reasonably close relation between castability and the grain-size distribution. The pH of the body compositions differed, but there was little or no change in its value with the age of the casting slip up to 96 hours. It is concluded that the determination of grain size and pH should be of considerable aid in the control of casting slips.

I. Introduction

There are so many factors affecting the castability of clay slips that it is difficult, if not impossible, to control all variables so that any two or more properties may be correlated.

The control of casting is more important in the production of heavy castings, such as sanitary ware and electrical porcelain, than in dinnerware. On the other hand, although the data obtained in this study pertained particularly to sanitary porcelain slips, conclusions based on such data should apply equally well to all types of whiteware casting slips.

Among the factors recognized as affecting castability are grain size, base-exchange capacity, soluble salts, and pH of the materials composing the body slip; the viscosity (or consistency), specific gravity, temperature, and age of the slip; and the composition and amount of the electrolyte used.

II. Procedure

(1) Preparation of Casting Slips

To compare the effect of individual clays, nine sanitary porcelain bodies were prepared, each containing a single material of each type. Each of the bodies contained 25% of china clay, ball clay, flint, and feldspar.

* Presented at the Joint Autumn Meeting, White Wares and Materials and Equipment Divisions, American Ceramic Society, Uniontown, Pa., September 15, 1939. Received September 28, 1939.

The china clay in bodies No. 1 to No. 5 was No. 30 of the English China Clay Sales Corporation. This was replaced in bodies No. 6 to No. 9 with "Kamec" N. C. kaolin.

The ball clays in these bodies were as follows:

Body No.	Ball clay
1 and 6	Higman's No. 12 English
2	New Wade, Tenn.
3 and 7	Equal parts, Ky. O. M. No. 4, and Ky. No. 12
4 and 8	Martin, Tenn.
5 and 9	Jernigan, Tenn.

Six kilograms of each body were prepared by blunging with distilled water, lawning, and dewatering to plastic consistency in plaster bowls.

The casting slips were prepared from the plastic bodies by blunging in a ball mill with a few pebbles after adding the required distilled water and electrolyte. The ball mill was used for blunging and for storage while aging between tests to avoid loss of water after adjusting the specific gravity.

The electrolyte used was a mixture of 60% "N" brand sodium silicate and 40% sodium carbonate on a dry basis.

The electrolyte was added in increments to each body until trial casts drained properly and had the right "feel." The casting slips of each body were blunged for three hours when the electrolyte was added and again before testing after each aging period.

(2) Tests

(*A*) *Grain Size:* The grain size was determined with the Andreasen pipette,[1] using a sample of the plastic body dispersed in distilled water with sodium pyrophosphate to a 1% suspension.

This gave the true grain size rather than an apparent or fictitious one which would be obtained from the partially diluted casting slip. In any case, it would be necessary to have close to a 1% suspension, and it would thus be difficult to reproduce the degree of deflocculation of the slips as used in casting.

(*B*) *Consistency:* The consistency or viscosity determinations were made with the Irwin consistometer.[2]

(*C*) *Casting Rate:* The casting rate was determined by taking the average dry weight of cast of three small cups. The cup molds, filled with the slip, stood for 30 minutes and drained for 10 minutes. The percentage of water retained by the cast in terms of the wet weight was determined on these cups.

Hydrogen-ion determinations were made with a glass electrode pH meter when the casting slip was first prepared and at the end of 24-, 48-, and 96-hour aging periods.

III. Discussion of Results

Figure 1 shows a typical set of the consistency graphs. The zero yield value may be attributed to the electrolyte. Body slips, made thin enough to flow with water alone, were found to have a pronounced yield value.

The effect of other electrolytes on the yield value were not determined in this investigation. Cooke[3] found that sodium silicate caused zero yield value in enamel slips, whereas various inorganic salts either decreased or increased it, compared with the value obtained without such additions.

The results of all of the tests are shown in Table I.

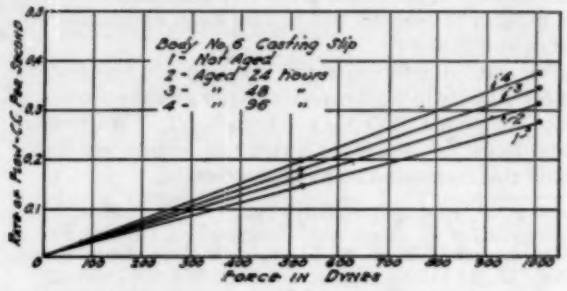

FIG. 1.—Consistency graphs obtained with Irwin consistometer.

The percentage of electrolyte, adjusted in each case to give a satisfactory cast according to the feel test, differed considerably with the different bodies. These percentages of both the electrolyte and the body were calculated on a dry basis. Body No. 2, containing New Wade, Tennessee, ball clay, required practically no electrolyte, and even the small amount introduced caused the slip to produce a hard cast. Body No. 4 was also inadvertently given slightly too much electrolyte.

With one exception, the specific gravity was adjusted between 1.82 and 1.83. Body No. 5 slip had a specific gravity of about 1.80.

The rate of flow as obtained with the shorter of the two capillaries of the consistometer is included in Table I. As all of the "F" values for this capillary were about the same and as the consistency graphs pass through the origin, these rates of flow give an idea of the mobility in comparison with the other results in each case. Most of the body slips had an increasing rate of flow with age. Body slip No. 1, however, fluctuated in rate of flow with age, whereas slip No. 8 decreased up to 48 hours of aging; at 96 hours, however, it had the same rate of flow as before aging. There was considerable difference in the rate of flow between the different slips.

The data on the dry weight of cast indicate that the casting rate of most of the slips tended to decrease slightly with age up to 96 hours. The bodies with the fastest casting rate had the coarsest grain size; this point will be discussed in detail later.

The percentage of water retained by the cast likewise tended to decrease slightly with the age of the slip.

[1] G. A. Loomis, "Grain Size of Whiteware Clays as Determined by the Andreasen Pipette," *Jour. Amer. Ceram. Soc.*, **21** [11] 393–99 (1938).

[2] J. T. Irwin and R. E. Bevis, "Modification of the Bingham Plastometer," *ibid.*, **21** [2] 66–68 (1938).

[3] R. D. Cooke, "Plastic Properties of Enamel Slip," *Jour. Amer. Ceram. Soc.*, **7** [9] 651–55 (1924).

As pointed out by Schramm and Hall,[4] it appears to be a good criterion of the condition of the slip for proper casting as indicated in the present investigation by the feel test. The proper numerical value, however, differs with different bodies.

The pH values changed only slightly in aging, but they had a tendency to become slightly lower with age. Up to 96 hours, however, the change was so slight that, contrary to prevalent opinion, the effect of adsorption in lowering the pH does not appear to be marked. On the other hand, there was considerable difference in pH between the different casting slips, due mainly to the difference in the pH of the bodies before the addition of electrolyte. On the whole, it would seem that, from the results obtained in this investigation, the pH should offer a reliable means of control of a casting slip of the same commercial body after a satisfactory value is established for this body, provided, of course, that account is taken of changes in the pH of the clays from shipment to shipment. It is realized that this statement is contrary to accepted belief, but the use of a reliable pH meter as an aid to control casting slips is worthy of further study in the industry.

The grain size, as indicated in Table I by percentages finer than 1 micron, appears to be fairly closely related to the rate of cast. There are one or two inconsistencies, notably that of No. 4 body slip, which had a slightly slower rate of cast than No. 5 but a coarser grain size than No. 5. This, however, is readily explained. It will be noted that the cast of body slip No. 4 had a hard "feel," which indicates that the electrolyte was in excess of the optimum amount as the rate of cast decreased and the cast became hard with increase in electrolyte content. This was clearly indicated in pilot tests of the bodies used in this study. As a matter of fact, body slip No. 4 in the previous study had a dry weight of cast of 221 grams, 19.3% water having been retained by the cast with 0.07% electrolyte. In this

[4] Edward Schramm and F. P. Hall, "Notes on Casting Slip," *Jour. Amer. Ceram. Soc.*, 17 [9] 262–67 (1934).

TABLE I

RESULTS OF TESTS

Body No.	Electrolyte (%)	Age of slip (hr.)	Specific gravity	Flow (cc./sec.)	Dry wt. of cast	Water retained in cast (%)	Feel	pH of slip	Grain size (% finer than 1 μ)
1	0	0						5.7	27.7
	0.03	0	1.823	0.485	140.5	17.7	O.K.	6.2	
	0.03	24	1.823	0.468	137.5	17.5		6.15	
	0.03	48	1.823	0.545	134.4	17.3		6.15	
	0.03	96	1.823	0.490	133.5	17.3		6.20	
2	0	0						4.75	29.5
	0.02	0	1.826	0.564	116.6	16.2	Hard	4.95	
	0.02	24	1.826	0.592	113.4	16.1		4.95	
	0.02	48	1.826	0.592	109.9	16.3		4.95	
	0.02	96	1.826	0.603	106.4	16.1		5.05	
3	0	0						5.60	26.5
	0.03	0	1.826	0.299	132.6	18.2	O.K.	6.10	
	0.03	24	1.826	0.311	134.3	18.6		6.0	
	0.03	48	1.826	0.312	139.2	18.9		5.9	
	0.03	96	1.826	0.369	136.7	18.6		5.85	
4	0	0						6.8	18.0
	0.08	0	1.834	0.236	163.6	18.3	Hard	8.45	
	0.08	24	1.834	0.307	165.7	18.2		8.20	
	0.08	48	1.834	0.326	147.7	17.7		8.05	
5	0	0						4.2	22.7
	0.12	0	1.802	0.360	184.6	19.9	O.K.	6.1	
	0.12	24	1.802	0.413	171.3	19.6		6.0	
	0.12	48	1.802	0.418	169.6	19.5		5.95	
	0.12	96	1.802	0.477	171.5	19.4		5.9	
6	0	0						5.85	31.2
	0.06	0	1.823	0.277	115.4	17.5	Slightly soft	6.55	
	0.06	24	1.823	0.313	114.4	17.4		6.40	
	0.06	48	1.823	0.344	106.3	16.9		6.45	
	0.06	96	1.823	0.376	106.7	16.6		6.40	
7	0	0						6.10	29.1
	0.07	0	1.826	0.248	115.0	18.0	O.K.	6.50	
	0.07	24	1.826	0.272	116.4	17.9		6.65	
	0.07	48	1.826	0.268	112.8	17.9		6.60	
	0.07	96	1.826	0.299	111.9	17.9		6.30	
8	0	0						6.90	22.7
	0.06	0	1.823	0.377	170.8	18.7	O.K.	7.70	
	0.06	24	1.823	0.356	166.2	18.6		7.65	
	0.06	48	1.823	0.350	161.2	18.6		7.70	
	0.06	96	1.823	0.377	166.3	18.3		7.60	
9	0	0						5.0	24.7
	0.16	0	1.820	0.311	169.7	19.1	O.K.	6.7	
	0.16	24	1.820	0.315	160.0	19.0		6.6	
	0.16	48	1.820	0.337	159.7	18.9		6.6	
	0.16	96	1.820	0.375	160.3	18.8		6.6	

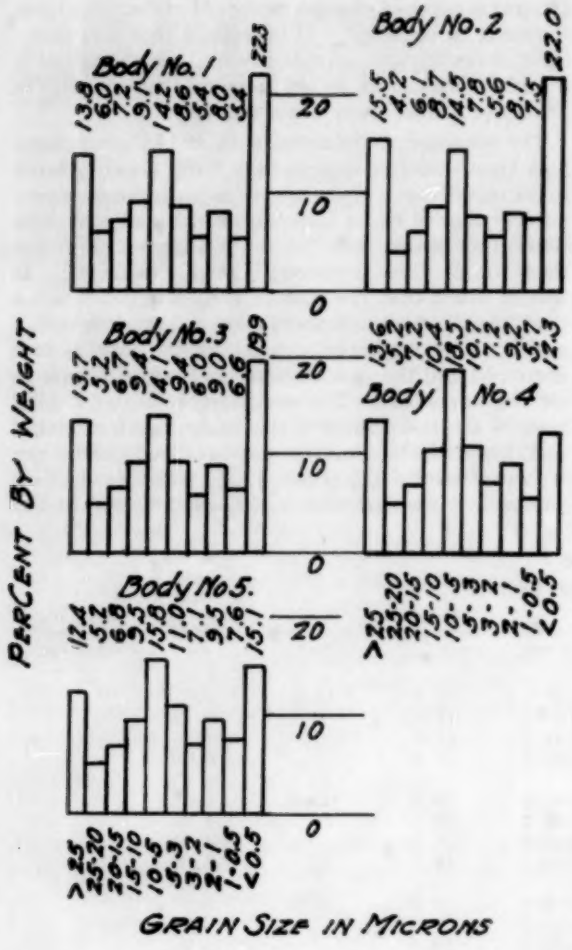

FIG. 2.

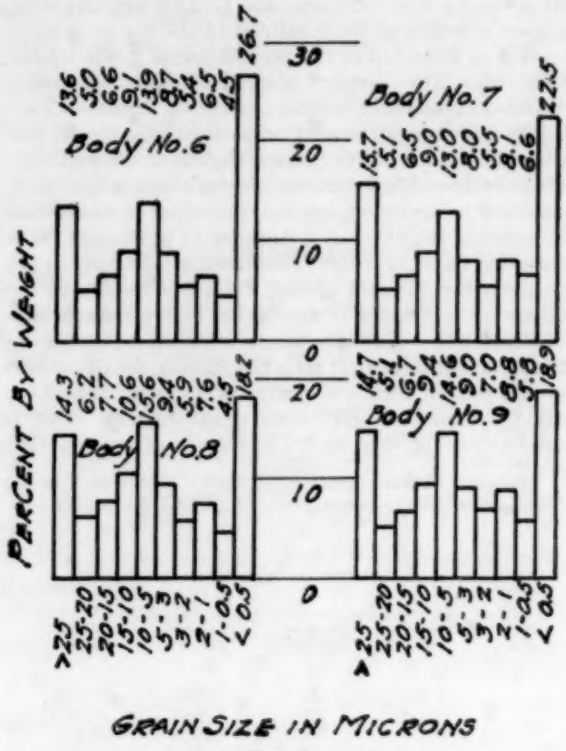

FIG. 3.

case, the cast was slightly soft although the drainage was good.

The complete grain-size distribution of the bodies used is shown in Figs. 2 and 3.

There is little difference in the coarser fractions, practically all of the difference being in the fraction 0.05 to 0 micron. The sum of the two finest fractions, however, that is, the percentage finer than 1 micron, bears a closer relation to the casting rate than does the finest fraction considered alone.

IV. Conclusions

The conclusions which seem to be warranted according to the results of this study of sanitary porcelain casting slips are as follows:

(1) The grain size of a body slip, especially the percentage finer than 1 micron, bears a fairly close relation to the casting rate of the slip when the condition of the slip is such as to produce a cast with the correct feel or degree of plasticity. Other factors being equal, the lower the percentage finer than 1 micron, the higher the rate of cast.

(2) The pH of a casting slip does not change greatly with age up to 96 hours, but there may be a considerable difference in this value between different bodies because of the difference in the pH of the materials used.

(3) The determination of the grain size and the pH of the raw materials, bodies, and casting slips should be of material aid in the control of casting slips.

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EVALUATION OF GLAZE-FIT TEST METHODS*

By W. C. Bell

Abstract

The various glaze-fit test methods are described, and the results of the ring, flat-plate, and tuning-fork tests on semivitreous types of bodies and glazes are compared.

I. Introduction

Various test methods have been developed to determine the stress existing in ceramic bodies and glazes. These tests are of value principally to determine the ability of glazed ware to withstand delayed crazing. This form of crazing is dependent on a number of different factors which include (1) the moisture expansion of the body, (2) the stress in the glaze, (3) the delayed contraction of the glaze, and (4) the character of the glaze-body interface.

II. Test Procedure

(1) Ring Test

The first method considered was the ring test in which two sizes of rings have been used. Schurecht and Pole[1] used a ring with an outside diameter of 2 inches (fired), and the Davis and Lueders[2] ring was 3 inches in outside diameter. A compromise was made in the present tests, and rings were used which were $2^3/_4$ inches in outside diameter, $^1/_2$ inch high, and $^1/_4$ inch in wall thickness (fired dimensions). Measurement lugs and capillary tubes were cemented on the top of the rings to serve as reference points, but they were found to be unsatisfactory. The lugs were not sufficiently accurate, and the capillary tubes were not easy to apply and were rather hard to measure.

The reference points finally adopted consisted of two small tabs of 0.004-inch shim brass. The tabs were cemented on the top of the ring with a Glyptal cement. The reference points consisted of a cross, cut on each tab with a razor blade, and could be applied rapidly and easily. A point on one arm of each cross was taken as a reference point, whereas the other arm of each cross afforded a perfect alignment of the reference points with the cross in the microscope used for the measurements. By this precise method, readings could be checked easily to ±0.004 millimeter.

(2) Flat-Plate Test

The next test method considered was the tile or flat-plate test reported by Hagar and Schofield.[3] The test specimens were similar in shape to wall tile without the ridge on the back, and their fired dimensions were 4 by 2 by $^3/_{16}$ inches. The warpage of the tile was measured with the instrument shown in Fig. 1. An Ames dial calibrated in thousandths of an inch was used. The warpage could be read to 0.001 inch and estimated to ± 0.0001 inch.

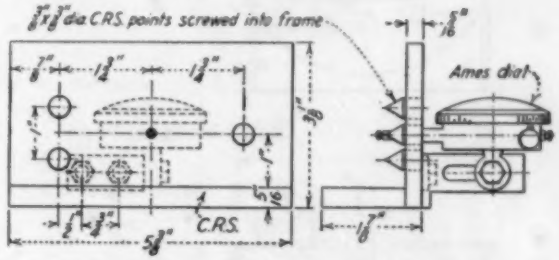

Fig. 1.—Flat-plate apparatus.

(3) Tuning-Fork Test

The final group of test methods was an adaptation of the Steger method.[4] The first test considered was the tuning-fork method reported by Blakely,[5] and with minor adjustments, the test specimens and testing furnace were similar to those which he used.

The second method in this group was similar to the Steger apparatus, but it was adapted after a test method used by Morgan.[6] The construction of the furnace and the shape of the test specimen are given in Fig. 2. A scale calibrated in 0.10 millimeter, with readings made with a magnifying glass, was used initially to measure the deflection of the test specimen. More accurate readings were obtained with a cathetometer. Because the data obtained with this test method duplicated the type of curve found by the tuning-fork method, this method has been omitted.

In this investigation, the stress present in the glaze was measured as the test specimens came from the kiln

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[1] H. G. Schurecht and G. R. Pole, "Method of Measuring Strains Between Glazes and Ceramic Bodies," *Jour. Amer. Ceram. Soc.*, **13** [6] 369–75 (1930).

[2] H. E. Davis and R. L. Lueders, "Simplification of Ring Method for Determining Glaze Stresses," *ibid.*, **15** [1] 34–36 (1932).

[3] H. Z. Schofield, "Replacement of Cornwall Stone by Talc and Feldspar in a Wall-Tile Body," *Bull. Amer. Ceram. Soc.*, **16** [5] 203–204 (1937).

[4] (*a*) W. Steger, "Strain in Glazed Ware and Its Detection," *Ber. deut. keram. Ges.*, **9** [4] 203–15 (1928); *Ceram. Abs.*, **7** [9] 625 (1928).

(*b*) W. Steger, "Measuring Tension in Fired Ceramic Mixes," *Ber. deut. keram. Ges.*, **11** [3] 124 (1930); *Ceram. Abs.*, **10** [3] 206 (1931).

[5] A. M. Blakely, "Life History of a Glaze: II, Measurement of Stress in a Cooling Glaze," *Jour. Amer. Ceram. Soc.*, **21** [7] 243–51 (1938).

[6] W. R. Morgan, University of Illinois, personal communication.

rather than after a subsequent heat treatment. This was necessary to obtain data comparable with the other test methods. For this reason, the determinations were made on a heating schedule rather than on a cooling schedule, and the specimens were heated at the rate of 1½°C. per minute.

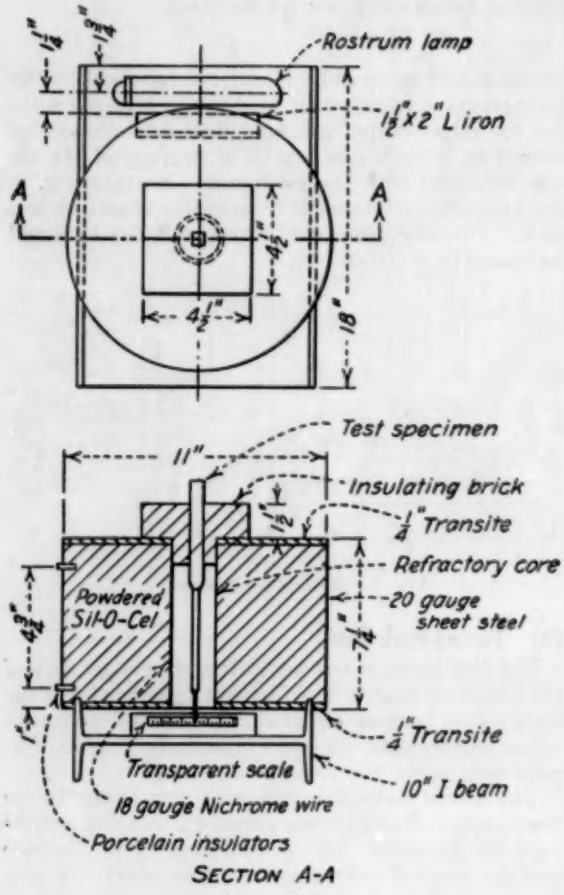

FIG. 2.—Steger test furnace.

III. Specimens Studied

Two commercial bodies and a number of glazes suitable for these bodies were used. One body was taken from the pug mill of a semivitreous dinnerware plant; the other, a fire-clay body, was taken from the pug mill of a plant which produces glazed brick.

All specimens were hand-wedged in brass molds. Because a flaw-free structure could not be obtained with the rings by hand molding, it was necessary to use plastic pressing. This was done by forcing a thin brass ring down into the mold in which the clay ring had been formed. This method, similar to dry pressing except that the excess clay was allowed to flow through the open end of the mold, produced a satisfactory specimen.

The flat-plate test was made on the fire-clay body, first by bisque-firing the body at cone 5^6 and by determining the warpage. The glaze was then applied, the specimens were refired, and the glaze-induced warpage was determined after the second firing.

The specimens of the semivitreous dinnerware body were bisque-fired to cones 9^3 and 10^3 and were glost-fired to cone 5^6.

For the fire-clay rings, the glaze was applied to the unfired test specimens, which were then fired to cone 5^6.

A pilot study was made to determine the extent of the effect, if any, of the glaze thickness on the stress in the glaze. Standard 4¼- by 2⅛-inch bisque wall tile were used, and different thicknesses of the same glaze were applied. The specimens were glost-fired to cone 5^6.

The stress values were determined for all of the test specimens, including the bisque specimens which were used for check tests. Autoclave tests were made on the flat-plate specimens and uncut fire-clay rings. The autoclave cycle for the semivitreous dinnerware body was a one-hour test at a steam pressure of 150 lb. per sq. in. The pressure was raised and lowered in one hour. The fire-clay specimens were given one three-hour autoclave test on a 5-hour cycle.

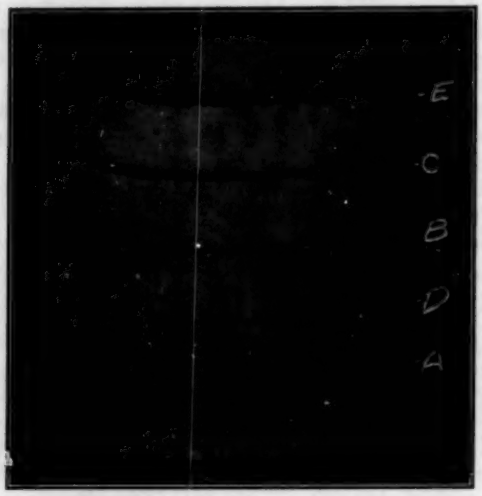

FIG. 3.—Autoclave fire-clay rings.

IV. Results

Table I shows the effect of glaze thickness on the glaze-induced warpage.

TABLE I

Glaze thickness (mm.)	Glaze-induced warpage (in.)
0.13	−0.0044
0.24	−0.0050
0.37	−0.0055

Concave warpage (+) and convex warpage (−) on glaze face of flat plate; (−) indicates compression in glaze.

(1) Flat-Plate Test

The results obtained by the flat-plate method for the one-fire, fire-clay body and glazes were not satisfactory.

GLAZE NO. 1

Glaze formula

$$\left.\begin{matrix}0.1600\ K_2O\\0.0512\ Na_2O\\0.4350\ CaO\\0.3560\ PbO\end{matrix}\right\}\ 0.298\ Al_2O_3\ \left\{\begin{matrix}2.95\ SiO_2\\0.291\ B_2O_3\end{matrix}\right.$$

Frit formula

$$\left.\begin{matrix}0.250\ K_2O\\0.078\ Na_2O\\0.390\ CaO\\0.281\ PbO\end{matrix}\right\}\ 0.249\ Al_2O_3\ \left\{\begin{matrix}1.495\ SiO_2\\0.454\ B_2O_3\end{matrix}\right.$$

GLAZE NO. 2

Glaze formula

$$\left.\begin{matrix}0.1600\ K_2O\\0.0512\ Na_2O\\0.4350\ CaO\\0.3560\ PbO\end{matrix}\right\}\ 0.298\ Al_2O_3\ \left\{\begin{matrix}2.95\ SiO_2\\0.291\ B_2O_3\end{matrix}\right.$$

Frit formula

$$\left.\begin{matrix}0.285\ K_2O\\0.091\ Na_2O\\0.624\ CaO\end{matrix}\right\}\ 0.285\ Al_2O_3\ \left\{\begin{matrix}1.71\ SiO_2\\0.519\ B_2O_3\end{matrix}\right.$$

PbO added as lead bisilicate.

GLAZE NO. 3

Glaze formula

$$\left.\begin{matrix}0.34\ PbO\\0.07\ Na_2O\\0.14\ K_2O\\0.35\ CaO\\0.10\ ZnO\end{matrix}\right\}\ 0.27\ Al_2O_3\ \left\{\begin{matrix}2.6\ SiO_2\\0.20\ B_2O_3\end{matrix}\right.$$

Frit formula

$$\left.\begin{matrix}0.12\ PbO\\0.03\ Na_2O\\0.06\ K_2O\\0.12\ CaO\end{matrix}\right\}\ 0.09\ Al_2O_3\ \left\{\begin{matrix}0.72\ SiO_2\\0.20\ B_2O_3\end{matrix}\right.$$

GLAZE NO. 4

Glaze batch	(%)	Frit batch	(%)
Frit	55.6	Borax	35.7
Feldspar	11.1	Flint	22.0
Flint	11.1	Feldspar	8.3
White lead	22.2	Whiting	13.7
		Soda ash	6.6
		China clay	13.7

GLAZE NO. 5

Glaze batch	(%)	Frit batch	(%)
Frit	48.6	Borax	41.5
Feldspar	15.8	Flint	24.4
Flint	2.61	Feldspar	24.4
White lead	33.00	Whiting	9.76

GLAZE NO. 6

Glaze formula

$$\left.\begin{matrix}0.605\ PbO\\0.142\ CaO\\0.253\ K_2O\end{matrix}\right\}\ 0.253\ Al_2O_3\ \ 1.541\ SiO_2$$

GLAZE NO. 7

Glaze formula

$$\left.\begin{matrix}0.18\ PbO\\0.14\ Na_2O\\0.07\ K_2O\\0.48\ (CaMg)O\\0.13\ ZnO\end{matrix}\right\}\ 0.27\ Al_2O_3\ \left\{\begin{matrix}2.6\ SiO_2\\0.36\ B_2O_3\end{matrix}\right.$$

Frit formula

$$\left.\begin{matrix}0.06\ PbO\\0.06\ Na_2O\\0.03\ K_2O\\0.24\ (CaMg)O\end{matrix}\right\}\ 0.09\ Al_2O_3\ \left\{\begin{matrix}0.72\ SiO\\0.36\ B_2O_3\end{matrix}\right.$$

GLAZE NO. 8

Glaze formula

$$\left.\begin{matrix}0.26\ PbO\\0.06\ Na_2O\\0.12\ K_2O\\0.43\ CaO\\0.13\ ZnO\end{matrix}\right\}\ 0.27\ Al_2O_3\ \left\{\begin{matrix}2.6\ SiO_2\\0.31\ B_2O_3\end{matrix}\right.$$

Frit formula

$$\left.\begin{matrix}0.050\ PbO\\0.028\ Na_2O\\0.031\ K_2O\\0.357\ CaO\end{matrix}\right\}\ 0.059\ Al_2O_3\ \left\{\begin{matrix}0.838\ SiO_2\\0.310\ B_2O_3\end{matrix}\right.$$

GLAZE NO. 9

Glaze batch	(%)	Lead frit "A"	(%)
Lead frit "A"	30.76	White lead	56.439
Leadless frit "B"	27.85	Whiting	3.855
Whiting	9.488	English china clay	16.571
ZnO	3.094	Flint	23.135
English china clay	7.059		
Flint	21.752		

Leadless frit "B"	(%)
Whiting	4.633
Pearl ash	12.794
Borax	17.656
Aluminous hydrate	12.035
Flint	34.751
Boric acid	18.131

This indicates that when the glost temperature equals or approaches the bisque temperature, there is sufficient warpage of the body itself to interfere with an accurate determination of the glaze-induced warpage.

The results obtained with two-fire glazes were satisfactory, whereas those obtained for the one-fire, fire-clay body and glazes were unsatisfactory.

(2) Ring Test

The results obtained with the ring test were satisfactory. Figure 3 shows that in every case there is good agreement between the stress in the glaze and the tendency to craze.

TABLE II

Glaze No.	Contraction or expansion of rings (mm.)
A	+0.1057
D	+0.0965
B	+0.0440
C	−0.0601
E	−0.1368

Contraction (−) and expansion (+) of rings; (−) indicates compression in glaze.

(3) Tuning-Fork Test

The stress curves obtained with the tuning forks are given in Table III and in Fig. 4.

TABLE III

COMPARISON OF TEST RESULTS

Glaze No.	Bisque maturing temp. (cone 9[a])	Rings (mm.)	Flat plate (in.)	Tuning forks glaze stress* (kg./mm.²)	Autoclave test 150 lb./sq. in. for 1 hr. 1st cycle	2nd cycle	3rd cycle
1		−0.180	−0.0025	−3.24	Crazed		
2		− .235	− .0030		"		
3		− .3000	− .0040		Slight crazing		
	(Cone 10[a])						
4		+ .030	+ .0015		Extreme crazing		
5		− .020	− .0003		" "		
6		− .172	− .0024	−3.89	No failure	Slight crazing	
7		− .320	− .0055		" "	No failure crazed	
8		− .330	− .0035	−7.35	" "	" "	"
9		− .360	− .0040	−7.49	" "	" "	"

Contraction (−); expansion (+) of rings.
Concave warpage (+); convex warpage (−) on glaze face of flat plate.
* Stress where specimen is allowed to bend; (−) compression in glaze.

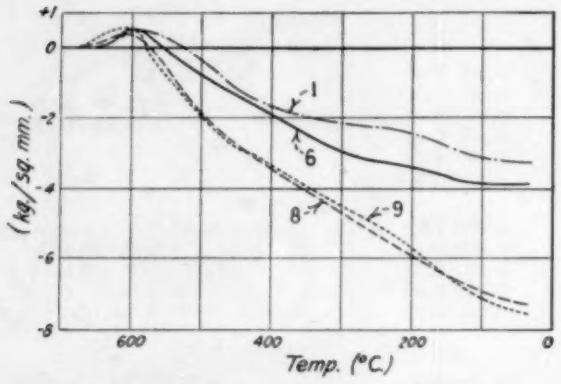

FIG. 4.—Stress curves with tuning fork.

In general, there is a definite correlation between the glaze stress and the resistance to crazing. The glazes in tension and in low compression were extremely susceptible to crazing. Although the body was underfired, glazes Nos. 1, 2, and 3 had better crazing resistance than some of those that were properly fired but on which the glaze was in tension or low compression, e.g., glazes Nos. 4 and 5. There is also a great difference in the crazing resistance of the specimens that were properly fired. The glazes in high compression withstood two more autoclave cycles than those in tension or in low compression.

Although there is a somewhat different principle involved in each of the tests, the results obtained by the various test methods in general are in agreement. The thickness of the glaze film does have an effect on the glaze-induced warpage.

V. Conclusions

(1) The ring test is suitable for qualitative measurements of glaze stress. Satisfactory values may be obtained regardless of the difference between bisque and glost-firing temperatures.

(2) The flat-plate test requires little equipment and is rapid and quite accurate for two-fire glazes, but it is not satisfactory for one-fire glazes.

(3) The tuning-fork test is satisfactory chiefly as a laboratory test in the study of the development of stress in the glaze on cooling, but it requires expensive equipment and considerable time, and the test specimens are difficult to fire without producing warpage.

Acknowledgment

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ZINC-VAPOR GLAZING OF CLAYS: II, EFFECT OF VARIABLE LIME AND ALKALIS IN CLAYS ON ZINC-VAPOR GLAZE COLORS*

By C. Major Lampman and H. G. Schurecht

Abstract

A study was made of the influence of the lime content of brick on their ability to take zinc-green, yellow, tan, and brown glazes. Desirable greens were obtained with clays containing as much as 3% lime; those with a higher percentage of lime generally produced yellow-greens. The probability of obtaining good greens was best on clays with more than 6% of alkalis when their absorptions after firing were below 2%. Desirable greens were not obtained on bodies which had absorptions greater than 6.7%. Firing under oxidizing conditions before flashing and slow cooling tended to promote the formation of desirable brown, tan, and straw-colored zinc-vapor glazes.

I. Introduction

As the lime content in brick is increased, it is known that yellow-green glaze flash colors are produced instead of the more desirable blue-green colors. The maximum lime content, however, of clays still capable of producing pleasing green colors as well as the content necessary to produce desirable yellow or straw colors has never been determined. The method of firing and flashing which tends to produce the best yellow and tan colors likewise has never been definitely ascertained. The purpose of this work, therefore, was to determine the effect of variable lime and alkali contents in brick clays on zinc-vapor colors as well as the influence of the degree of vitrification of bodies on the colors obtained. The effect of variations in the methods of flashing and cooling zinc-flash colors were also studied.

II. Experimental Procedure

Impure clays, containing varying amounts of lime, iron oxide, and alkalis, were prepared by mixing these impurities with relatively pure clays (see Tables I and II). They were molded into cylinders, 2 inches high and $^1/_2$ inch in diameter, which were mounted in fireclay plaques. These were sent to five different plants where they were zinc-vapor glazed in commercial kilns. The methods of zinc flashing employed at these plants were the same as those described in Part I of this series.[1]

At plants Nos. 1 and 3, the kilns were fired strongly reducing just before zinc flashing and were cooled slowly.

III. Results

The results are shown in Figs. 1, 2, 3, and 4, in which the colors and glazes obtained as well as the absorptions of the bodies are shown graphically.

IV. Discussion of Results

It is evident that desirable greens may be obtained on bodies with from 0% to about 6% absorption, 0.2 to 5% of lime, and 4 to 11% of alkalis under slightly less favorable conditions.

Pleasing yellow-greens and straw-colored glazes were obtained on bodies with from 0% to about 5% absorption, 4 to 6% of lime, and 4 to 11% of alkalis. The conditions for obtaining yellow-greens were similar to those for producing blue-greens except that the lime content was higher, that is, from 4 to 6% in place of 0.2 to 4%.

Brown-greens were obtained on bodies with from 0% to about 18% absorption, 0.2 to 6% of lime, and 1 to 11% of alkalis.

Green-tans were produced on bodies with 5% to about 18% absorption, 0.2 to 3% of lime, and 1 to 11% of alkalis.

Tan colored zinc-vapor glazes were obtained on bodies with from 6% to about 18% absorption, 0.2 to 6% of lime, and 1 to 11% of alkalis under favorable conditions of flashing and cooling.

Browns were produced on bodies with from 10% to about 22% absorption, 0.2 to 6% of lime, and 1% to about 11% of alkalis. Browns and tans were obtained best when they were fired oxidizing before zinc flashing and also when the kilns were cooled slowly.

The compositions capable of producing the different colored glazes overlap, depending on the methods employed in firing, flashing, and cooling the kilns. For example, under favorable conditions, pleasing greens were obtained with the lime content as high as 5% in terms of calcined weight of the clay. Under less desirable conditions, however, yellow-greens were obtained when the lime content was slightly more than 2.5%; whereas under conditions still less favorable, no green colors were obtained, but yellows and tans were produced on all specimens. This illustrates the importance of methods of flashing and cooling on the colors obtainable.

Pleasing greens were obtained on bodies with an absorption as high as 6.7%, under the proper conditions of firing, flashing, and cooling. Under less favorable conditions, however, an absorption of less than 2% may be necessary to develop good greens. A study of the probabilities of a body taking green or yellow-green vapor glazes therefore appeared to be important in the analyses of these results.

For this study, the specimens fired at the four plants

* Presented at the Forty-First Annual Meeting, American Ceramic Society, Chicago, Ill., April 19, 1939 (Structural Clay Products Division). Received February 10, 1940.

[1] C. M. Lampman and H. G. Schurecht, "Zinc-Vapor Glazing of Clays: I, Effect of Variable Iron Oxide and Alkalis in Clays on Zinc-Vapor Glaze Colors," *Jour. Amer. Ceram. Soc.*, **22** [3] 91–95 (1939).

were classified into different groups with varying lime and alkali contents. These were further subdivided into groups with 0 to 2%, 2 to 5%, and 5 to 9% absorptions, respectively. The following equation was used to calculate their probabilities of taking green or yellow-green vapor glazes:

$$P = \frac{a}{a+b}, P' = \frac{c}{c+d}.$$

Wherein P = probability of taking green vapor glaze.
a = specimens taking green vapor glaze.
b = specimens not taking green vapor glaze.
P' = probability of taking yellow-green vapor glaze.
c = specimens taking yellow-green vapor glaze.
d = specimens not taking yellow-green vapor glaze.

The results of this analysis on the formation of true greens and yellow-greens are shown in Figs. 3 and 4. The probability of obtaining good greens is improved by keeping the absorption below 2%. As the lime content is increased, the percentage of specimens taking a true green is decreased because of their tendency to develop yellow-green colored glazes.

When the lime content is more than 3.72%, the tendency of these bodies to develop yellow-greens is very strong. In many cases, however, the lime content may be as high as 3% without destroying the desirable blue-green colors.

At one plant, when the specimens were salt-glazed at 2060°F. and then flashed at the same temperature, brown glazes were obtained. In another test, when the same specimens were salt-glazed at 2060°F. and then the kiln temperature was dropped to 1950°F. before zinc flashing, more than 80% of these specimens developed good greens. Lowering the temperature of the kiln 110°F. below the finishing temperature before zinc flashing apparently facilitates the formation of green zinc-vapor glazes. These tests were conducted

TABLE I

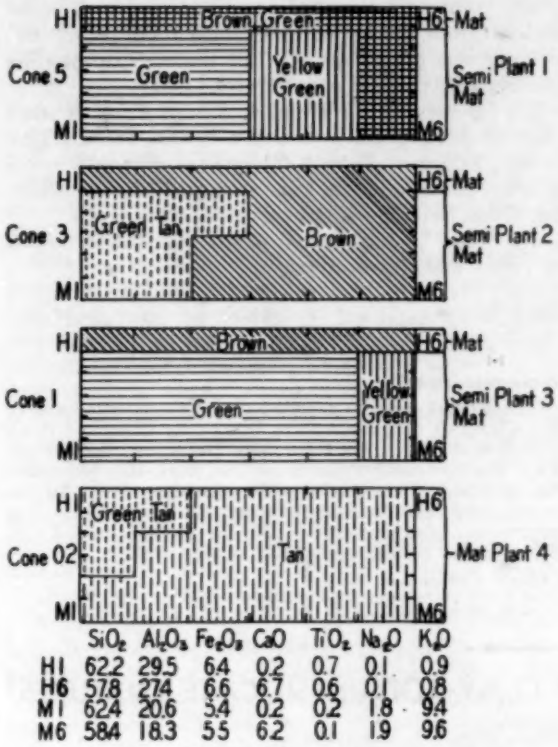
BATCH WEIGHTS OF BODIES

Body No.	Georgia kaolin	Kentucky ball clay	Potter's flint	Buck-ingham feldspar	Iron oxide	Whiting
			Body H			
1	31.67	31.66	31.67	0	5.00	0
2	30.97	30.90	31.01	"	"	2
3	30.31	30.32	30.34	"	"	4
4	29.65	29.66	29.67	"	"	6
5	28.99	29.00	29.00	"	"	8
6	28.33	28.34	28.33	"	"	10
			Body I			
1	26.98	27.00	26.98	14	"	0
2	26.32	26.32	26.32	"	"	2
3	25.66	25.65	25.68	"	"	4
4	25.00	24.98	25.00	"	"	6
5	24.34	24.31	24.34	"	"	8
6	23.68	23.64	23.68	"	"	10
			Body J			
1	22.31	22.35	22.31	28	"	0
2	21.65	21.66	21.65	"	"	2
3	20.99	20.99	20.99	"	"	4
4	20.33	20.32	20.33	"	"	6
5	19.67	19.65	19.67	"	"	8
6	19.01	18.98	19.01	"	"	10
			Body K			
1	17.64	17.70	17.64	42	"	0
2	16.98	16.96	16.98	"	"	2
3	16.32	16.30	16.32	"	"	4
4	15.66	15.64	15.66	"	"	6
5	15.00	14.98	15.00	"	"	8
6	14.34	14.32	14.34	"	"	10
			Body L			
1	12.97	13.05	12.97	56	"	0
2	12.31	12.38	12.31	"	"	2
3	11.65	11.70	11.65	"	"	4
4	10.99	11.02	10.99	"	"	6
5	10.33	10.34	10.33	"	"	8
6	9.67	9.66	9.67	"	"	10
			Body M			
1	8.30	8.40	8.30	70	"	0
2	7.64	7.72	7.64	"	"	2
3	6.98	7.04	6.98	"	"	4
4	6.32	6.36	6.32	"	"	6
5	5.66	5.68	5.66	"	"	8
6	5.00	5.00	5.00	"	"	10

TABLE II

CHEMICAL COMPOSITIONS OF FIRED BODIES

Body No.	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	Na_2O	K_2O
				Body H				
1	62.27	29.46	6.40	0.69	0.23	Trace	0.04	0.91
2	61.40	29.07	6.43	0.68	1.48	"	0.05	0.89
3	60.55	28.66	6.46	0.67	2.73	"	0.05	0.88
4	59.67	28.26	6.49	0.66	4.02	"	0.03	0.87
5	58.79	27.84	6.53	0.64	5.32	"	0.03	0.85
6	57.87	27.41	6.55	0.64	6.66	"	0.03	0.84
				Body I				
1	62.34	27.53	6.19	0.58	0.23	"	0.42	2.71
2	61.45	27.12	6.20	0.57	1.45	"	0.50	2.71
3	60.53	26.71	6.23	0.55	2.69	"	0.58	2.71
4	59.63	26.26	6.26	0.55	3.94	"	0.66	2.70
5	58.71	25.83	6.28	0.53	5.22	"	0.73	2.70
6	57.73	25.38	6.31	0.52	6.53	"	0.83	2.70
				Body J				
1	62.35	25.75	5.98	0.47	0.23	"	0.78	4.44
2	61.51	25.26	6.00	0.47	1.43	"	0.87	4.46
3	60.64	24.82	6.02	0.45	2.65	"	0.95	4.47
4	59.75	24.37	6.05	0.44	3.88	"	1.02	4.49
5	58.84	23.92	6.07	0.42	5.14	"	1.11	4.50
6	57.87	23.52	6.09	0.41	6.41	"	1.19	4.51
				Body K				
1	62.41	23.98	5.78	0.36	0.21	"	1.13	6.13
2	61.53	23.54	5.80	0.35	1.40	"	1.22	6.16
3	60.67	23.09	5.82	0.34	2.60	"	1.30	6.18
4	59.78	22.63	5.84	0.34	3.82	"	1.38	6.21
5	58.89	22.17	5.86	0.32	5.06	"	1.47	6.23
6	57.97	21.71	5.88	0.31	6.32	"	1.56	6.25
				Body L				
1	62.45	22.56	5.58	0.26	0.21	"	1.48	7.76
2	61.20	21.68	5.57	0.25	1.37	"	1.56	7.76
3	60.73	21.36	5.62	0.24	2.56	"	1.65	7.84
4	59.86	20.90	5.64	0.23	3.77	"	1.72	7.88
5	58.99	20.44	5.66	0.21	4.98	"	1.81	7.91
6	58.10	19.96	5.68	0.21	6.21	"	1.90	7.94
				Body M				
1	62.47	20.58	5.40	0.17	0.21	"	1.81	9.36
2	61.68	20.14	5.43	0.16	1.36	"	1.82	9.41
3	60.95	19.71	5.44	0.15	2.53	"	1.76	9.46
4	60.08	19.25	5.46	0.13	3.72	"	1.85	9.51
5	59.25	18.80	5.48	0.12	4.93	"	1.86	9.56
6	58.41	18.34	5.50	0.11	6.15	"	1.88	9.61



	SiO_2	Al_2O_3	Fe_2O_3	CaO	TiO_2	Na_2O	K_2O
HI	62.2	29.5	6.4	0.2	0.7	0.1	0.9
H6	57.8	27.4	6.6	6.7	0.6	0.1	0.8
MI	62.4	20.6	5.4	0.2	0.2	1.8	9.4
M6	58.4	18.3	5.5	6.2	0.1	1.9	9.6

FIG. 1.—Effect of Fe_2O_3, CaO, and alkalis on zinc flash colors.

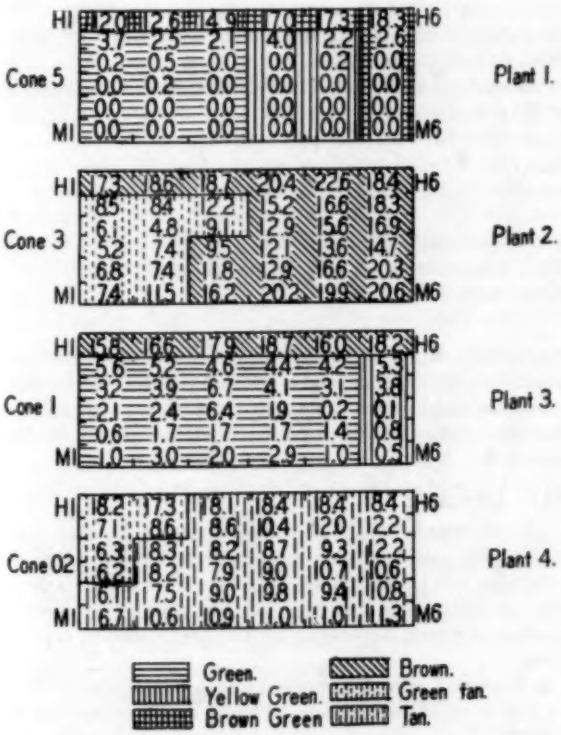


FIG. 2.—Effect of absorptions of bodies on zinc flash colors.

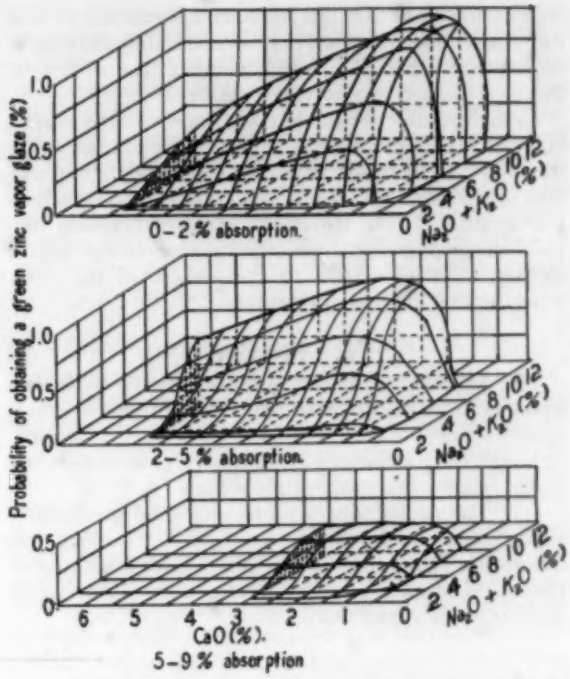


FIG. 3.—Effect of variable CaO and alkali contents and absorptions on the probabilities of obtaining green zinc flash colors.

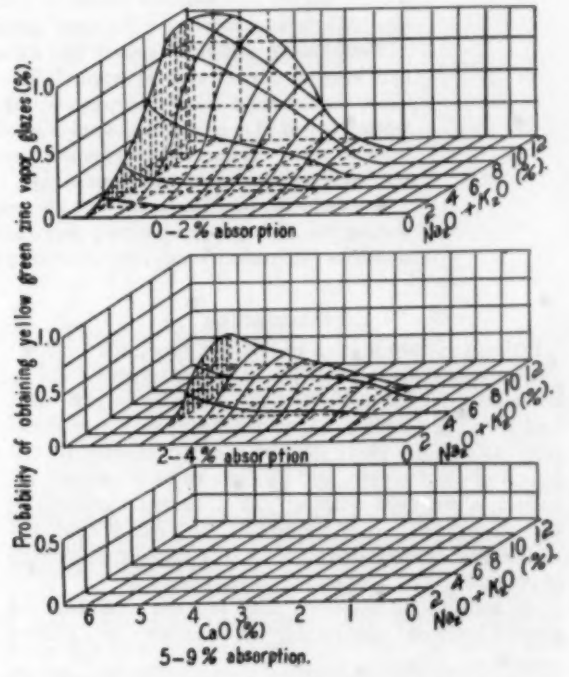


FIG. 4.—Effect of variable CaO and alkali contents and absorptions on the probabilities of obtaining yellow-green zinc flash colors.

only at one plant and therefore are not conclusive, but the results obtained were so encouraging that it is hoped that other plants will conduct trial runs with this new method of zinc-vapor glazing.

As high alkali contents in clays improve their probability of taking desirable zinc glazes, experiments were conducted to increase the alkalis deposited on the surface of the brick by adding about 0.5% common salt to the mixture. This treatment greatly increased the yield of good greens evidently because of the higher concentration of alkalis on the surface of the brick which tended to vitrify the surface.

V. Summary

The following summary applies strictly to bodies which contain about 58 to 62% of silica and approximately 5 to 7% of iron oxide in terms of calcined weight, although the conclusions also apply in general to many bodies outside this composition range.

(1) The probability of obtaining good green zinc-vapor glazes was greatly improved by keeping the absorption of the brick below 2%. Bodies with more than 6.7% absorption failed to take a green zinc-vapor glaze in these experiments.

(2) When the lime content was less than 3%, desirable green colors were obtained; but when this content was more than 4%, the tendency to produce yellow-green colors was greatly increased.

(3) Bodies with 6% alkalis showed a strong tendency to develop green as well as yellow-green glazes.

(4) Yellow and straw colors were obtained to the greatest extent when the kilns were fired strongly oxidizing before flashing with zinc.

(5) Slow cooling tended to promote the formation of yellow and straw colors.

(6) The introduction of 0.5% common salt into a brick body improved its ability to take good zinc-vapor glazes.

Acknowledgment

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MECHANISM OF THE HARDENING OF CLAY–SODIUM-SILICATE MIXTURES*

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Abstract

Acid salts, such as might be expected to be present in clays, reacted readily with sodium-silicate solutions and produced marked changes in viscosity out of contact with air. Magnesium salts gave the most gelatinous and bulky precipitates.

Experiments with fuller's earth and a plastic fire clay, which were free of soluble salts and were saturated with hydrogen, indicated that base-exchange reactions may also cause hardening of silicate mixtures out of contact with air. Natural plastic fire clays, which contained negligible amounts of soluble salts, were found to harden out of contact with air when calcium and magnesium were present as exchangeable bases, but they did not harden when these bases were absent.

It was found possible to prevent hardening of clay–sodium-silicate mixtures by subjecting the clay to a preliminary treatment with nonprecipitating sodium ions, introduced as sodium carbonate, before mixing the clay with sodium silicate.

I. Introduction

Sodium silicate is used in ceramic processes for various purposes, among which may be included its use as an electrolyte for regulating the viscosity of clay slips and as an air-setting agent for hardening refractory cements. Some clays do not respond readily to the action of electrolytes, and in some cases a variable response is observed without any apparent variation in the clay itself. Such variations may range from the thickening of clay suspensions to complete hardening of cements, the latter out of contact with air.

As sodium silicate itself may become unstable and either increase moderately in viscosity or harden completely, it is of interest to examine the various reactions which may cause sodium silicate to become unstable and to form a gel or a precipitate, thus affecting the viscosity or setting of clay–sodium-silicate mixtures.

(1) Literature

As reviewed by Vail,[1] the literature indicates that sodium-silicate solutions may form stable silica sols or unstable sols which change to gels and produce hardening or changes in viscosity, either rapidly or over a period of years, depending on the conditions of formation.

In general, silicate solutions which contain more than 4.2 mols of silica for each mol of sodium oxide will be

* Presented at the Forty-First Annual Meeting, American Ceramic Society, Chicago, Ill., April 18, 1939 (Refractories Division). Received March 13, 1940.

[1] J. G. Vail, Soluble Silicates in Industry. Chemical Catalog Co., New York, N. Y.

unstable and will gel on standing. Silica sols in which the molecular ratio of water to silica is 300 to 1 will form gels which set firmly and include all of the liquid. Sols in which the concentration of silica is as low as 1% may not gel in a year's time, but increased concentration causes the gel to form more quickly. Sols containing as much as 10% of silica are rare because of their instability. An increase in temperature, other conditions being equal, will also cause gels to form more rapidly.

Gels may form either in acid or alkaline solutions, but continued increase either in acidity or alkalinity will tend to stabilize the solution and cause the gel to form more slowly. Silicate solutions will react (1) with mineral acids and acid salts, (2) with all soluble compounds of metals which form insoluble silicates, and (3) with concentrated solutions of ammonium salts to form sols or gels, depending on the concentrations. Simple double-decomposition reactions seldom, if ever, occur, and complex products of uncertain composition are always formed, making stoichiometric calculations difficult. Complex products are also formed in the case of hydrolysis, and equilibrium is attained slowly, in some cases over a period of years.

Sodium-silicate solutions also react with solids, as indicated by the vigorous reaction of hot dilute solutions of $Na_2O \cdot 2SiO_2$, or more alkaline silicates with zinc and aluminum, although at ordinary temperatures and concentrations, the action is negligible. Calcium carbonate will not react with $Na_2O \cdot 4SiO_2$, but it will react with $Na_2O \cdot 2SiO_2$ mixtures with visible changes occurring within a few hours and, after a few weeks out of contact with air, the mixture will resist disintegration by water. Calcium phosphate, silica, calcined clay, zinc oxide, and other solids are said to react similarly. Calcium hydroxide will react with silicate solution to form a gel and Portland cement will react quickly with silicate solution in which the molecular ratio is less than 1 to 2.

In general, then, commercial solutions of sodium silicate might be expected to become unstable in use and to form gels or insoluble silicates by loss of water; by reaction with acids, alkalis, acid salts, and ammonium salts, all of which are soluble compounds of metals that form insoluble silicates; and by reactions in which hydrolysis plays a part.

(2) Field Covered

The present study is concerned with those reactions which might cause hardening of clay–sodium-silicate mixtures out of contact with air, although the same reactions might be expected to produce changes in the viscosity of casting slips.

In the first part of the study, the effect of various soluble salts, slightly soluble salts, and solids was determined on the gelation of sodium-silicate solutions.

The second part of the work consisted of the study of the effect of base-exchange reactions on the hardening of clay–sodium-silicate mixtures.

II. Procedure and Results

(1) Test Conditions

Although some clay–sodium-silicate mixtures were known to harden slowly out of contact with air, it was necessary to accelerate the reactions and to establish a satisfactory treatment which would produce hardening in a reasonable time. This was done by subjecting mixtures, which were known to harden slowly, to temperatures somewhat above atmospheric for various lengths of time. Although hardening took place more rapidly at the higher temperatures, a satisfactory seal was difficult to maintain because of excessive vapor pressure of the mixture. Satisfactory hardening was produced by holding the mixture in a sealed container at 60°C. for three days, and this procedure was adopted.

(2) Stability of the Silicate Solutions

Commercial solutions of sodium silicate were used, in which the ratio of silica to soda varied from 1.95 to 3.50. All of the solutions would be expected to be stable, and they would not be expected to harden when standing out of contact with air. As a further check on this test procedure, silicate solutions of different dilutions, corresponding to those to be used in later tests, were sealed in containers and held at 60°C. for several weeks. No gelation occurred in any case, indicating that gelation would not be caused by loss of moisture and that the test procedure was satisfactory.

The composition of the commercial sodium-silicate solutions and the concentration of the diluted solutions are given in Table I.

TABLE I

COMPOSITION OF COMMERCIAL SODIUM SILICATE

Grade	Composition by weight (%)				Molality (SiO_2)
	Na_2O	SiO_2	SiO_2:Na_2O	Water	
2X	6.35	22.6	3.50	71.05	5.30
JM	9.1	29.6	3.25	61.3	8.05
14	11.2	31.9	2.85	56.9	9.33
16	13.9	33.1	2.38	53.0	10.39
6	18.4	36.0	1.95	45.6	13.12

DILUTED SODIUM-SILICATE SOLUTIONS

Grade	Molal concentration of SiO_2						
2X	1.0	2.0	5.3				
JM	1.0	2.0	5.3	8.05			
14	1.0	2.0	5.3	8.05	9.33		
16	1.0	2.0	5.3	8.05	9.33	10.39	
6	1.0	2.0	5.3	8.05	9.33	10.39	13.12

(3) Effect of Soluble Salts

Although it was not expected that all of the soluble salts used would produce a precipitate with sodium silicate, they were tried in order to check the results reported in the literature and to determine the nature of the precipitate, if it was formed. Soluble salts were added in 0.5, 1.0, and 5.0% increments to each of the diluted sodium-silicate solutions, the percentage being calculated on the basis of the silica present in the solution (see Table II).

The amount of precipitate formed increased with the increasing amount of salt added. Of all the precipitates formed, those produced with magnesium sulfate and magnesium chloride were the most gelatinous and bulky, 1% of these salts being sufficient to solidify the entire mass. The precipitates, which were formed with

calcium chloride, were gelatinous and bulky but to a lesser extent than those with magnesium salts.

Ferrous sulfate gave an almost instantaneous reaction, producing a hard, dense precipitate.

TABLE II

EFFECT OF SOLUBLE SALTS

Salt added	Result	Salt added	Result
Sodium chloride	No ppt.	Barium chloride	Ppt.
Sodium carbonate	" "	Magnesium chloride	"
Sodium sulfate	" "	Magnesium sulfate	"
Potassium chloride	" "	Calcium chloride	"
Potassium carbonate	" "	Ferrous sulfate	"
Potassium sulfate	" "	Ammonium chloride	"

(4) Effect of Slightly Soluble Salts

When saturated solutions of slightly soluble salts were added to the diluted sodium-silicate solutions, they gave no precipitate (see Table III).

TABLE III

EFFECT OF SLIGHTLY SOLUBLE SALTS

Salt added	Solubility (gm./100 gm. cold water)	Result
Barium carbonate	0.0022	No ppt.
Barium sulfate	0.000115	" "
Calcium carbonate	0.0065	" "
Calcium sulfate	0.24	" "
Magnesium carbonate	0.0106	" "

(5) Effect of Solids

Table IV lists the solids which gave no precipitate when added to the diluted sodium-silicate solutions. The distinction between slightly soluble salts and solids is not a sharp one as some of the slightly soluble salts ordinarily are considered to be insoluble. It was possible to add a larger amount as a solid than as a saturated solution.

TABLE IV

EFFECT OF SOLIDS

Solid added	Solubility (gm./100 gm. cold water)	Result
Barium sulfate	0.000115	No ppt.
Ferrous carbonate	Insoluble	" "
Ferrous oxide	Insoluble	" "
Ferrous hydroxide	0.00067	" "
Iron disulfide	0.00049	" "
Ferric oxide	Insoluble	" "
Ferric hydroxide	Insoluble	" "
Ferric sulfate	Slightly soluble	" "
Rutile (TiO_2)	Insoluble	" "

(6) Base-Exchange Reactions

It has been shown that soluble salts react with sodium silicate to form gels or insoluble silicates. Inasmuch as clays contain soluble salts, the most obvious source of precipitating ions in clay–sodium-silicate mixtures would be the soluble salts in the clays themselves. Another possible source of precipitating cations also present in the clays might be the exchangeable bases.

Samples of fuller's earth and plastic fire clay were freed from soluble salts and were saturated with hydrogen by leaching with hydrochloric acid and by washing free from chlorides. When the materials prepared in this manner were mixed with sodium silicate, they hardened out of contact with air, indicating that hardening occurred because of the exchange of hydrogen for the sodium in the sodium silicate.

To show the mechanism of the reaction more clearly, additional samples of fuller's earth and plastic fire clay were freed from soluble salts and saturated with hydrogen as before. These materials, which reacted neutral to litmus, were mixed with a solution of sodium chloride which also reacted neutral to litmus. The mixture, however, was found to react acid to litmus, presumably because of the exchange of hydrogen in the fuller's earth and fire clay for the sodium in the salt solution. The mixtures were sufficiently acid to form a precipitate with sodium-silicate solution, which indicated that the base-exchange capacity of the materials was great enough to cause precipitation if the materials were saturated with precipitating ions, such as Ca^{++}, Mg^{++}, or H^{+}.

(7) Hardening and Nonhardening Clays Compared

Two commercial clays were selected. One of these was known to harden and the other did not harden when they were mixed with sodium silicate and sealed from contact with air. Qualitative tests were made for soluble salts and for exchangeable bases, the latter test being made by the ammonium-acetate method outlined by Graham and Sullivan.[2] Quantitative determinations of the base-exchange capacities of the clays were made by the barium-acetate method used by Joffe.[3] Table V shows the results of the tests.

TABLE V

CHARACTERISTICS OF CLAYS

	Nonhardening clay	Hardened clay
Base-exchange capacity (m.e./100 gm.)	10.1	13.3
Soluble salts (Ca, Mg, Fe)	Very slight	Very slight
Exchangeable bases (Ca, Mg)	None	Both

In the absence of appreciable amounts of soluble salts in both clays, but with the presence of exchangeable bases in the clay which hardened, it seems probable that the hardening of the clay was caused by the release of precipitating ions from the clay by exchange with the sodium silicate with which it was in contact.

(8) Prevention of Hardening

The hardening of a clay–sodium-silicate mixture, caused by a base-exchange reaction, should be prevented by saturating the clay with a nonprecipitating ion before mixing with sodium silicate. With this in mind, fuller's earth and a plastic fire clay, which had been saturated with hydrogen, were treated with nonprecipitating sodium ions, introduced as sodium car-

[2] R. P. Graham and J. D. Sullivan, "Critical Study of Methods of Determining Exchangeable Bases in Clay," *Jour. Amer. Ceram. Soc.*, **21** [5] 176–83 (1938).

[3] J. S. Joffe, Soil Lab., Agric. Expt. Sta., Rutgers University.

bonate. After the treatment, the materials were mixed with sodium silicate. No hardening of the samples occurred when they were sealed from contact with air. Similar samples, not subjected to the preliminary treatment, hardened as before.

As a further check, the natural clay which hardened in earlier tests was treated with sodium carbonate before it was mixed with sodium silicate and sealed from contact with air. No hardening occurred, indicating that the precipitating ions present as exchangeable bases in the clay had been effectively removed from the reaction by the sodium-carbonate treatment.

III. Summary and Conclusions

Sodium-silicate solutions may form gels or insoluble silicates by reaction with soluble salts of weak bases and strong acids which may be present in clays. Gels or insoluble silicates, in the absence of soluble salts, may be formed also by reaction with exchangeable bases present in clays. Such base-exchange reactions offer an explanation of the changes in the viscosity of clay slips, the variable response of a clay to sodium silicate, and the hardening of clay–sodium-silicate mixtures of a stiff-mud consistency, such as are used in refractory cements. It was found possible to prevent hardening by a preliminary treatment of the clay with nonprecipitating sodium ions, introduced as sodium carbonate, before mixing with sodium silicate.

Acknowledgment

Acknowledgment is made to the Grasselli Chemicals Department of E. I. du Pont de Nemours and Company, Cleveland, Ohio, and to their representative, R. F. Remler, for supplying the commercial silicate solutions which were used in the experimental work.

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CONTROL FOR LUMINOUS FLAME FIRING IN GLASS FURNACES*

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Abstract

Luminous-flame firing of natural gas in glass furnaces has been accomplished inefficiently and with difficulty for many years in an attempt to secure the advantages of the luminosity characteristics. Luminosity in the gas flame is now secured by retardation of combustion between overlying layers of air and gas, the resulting flame being particularly adapted for glassmelting. A successful method for controlling the length and shape of the luminous flame in a glass furnace involves the mixing of spent gases from the flue with the incoming fuel gas.

I. Introduction

Neither the luminous gas flame itself nor its utilization in commercial glassmelting furnaces is particularly new, inasmuch as this special kind of firing has been tried at various times for many years and in practically every type of furnace. In these experiments, many methods for securing luminosity were used and the luminous flame seemed to have well-defined advantages for glassmelting, but these advantages were completely nullified by the lack of any dependable means for controlling the flame. It is the purpose of this paper to discuss briefly the energy characteristics of the luminous flame, ways and means for the utilization of the luminous flame in glassmelting, and a method of control which meets the requirements of commercial glass-furnace operation.

Luminosity of a gas flame arises in the radiation from incandescent carbon particles, these particles resulting from the decomposition of the lighter hydrocarbons such as C_2H_4(ethylene), C_2H_6(ethane), and CH_4(methane). All of these gases are commonly found as constituents of natural gas and each has a relatively high rate of combustion, making it necessary to incorporate in all luminous-flame burners some means for retarding the mixing of the gas and air supply until the desired luminosity is obtained in the flame.

Luminosity is expressed as the emissivity of the flame, or the ratio of its energy radiation to that of a black body at the same temperature. A nonluminous flame has an emissivity ranging from 0.17 to 0.21; a luminous flame has an emissivity of approximately 0.70. The emissivity of a flame increases with the flame thickness, in accordance with an exponential law, but observation of a luminous flame with the blue glass or naked eye may be very misleading as far as the emissivity is concerned. For example, a luminous flame may be thick enough or dense enough to absorb ordinary light completely and yet be far from a complete absorber for thermal radiation of a longer wave length and, as a consequence, the emissivity of the flame is low.

The available radiation from a luminous flame is shown in Fig. 1, which indicates the small extent of the visible range as compared with the much greater field covered by radiant-carbon emission. The small CO_2 and H_2O bands, representing the gaseous radiation from a nonluminous flame, are also shown.

II. Luminous Flame Penetration in Glass

In Fig. 1, the range from zero to 3 μ is the field in which incandescent carbon radiation is a maximum.

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This field has also been indicated as radiant energy that penetrates the glass. In Fig. 2, which shows the energy transmission curves for three glasses at various wave lengths, it is interesting to note that the maximum transmission values also fall in the range of zero to 3 μ. These figures, of course, are for glass at approximately room temperature, but the mere fact that the luminous flame has strong radiation characteristics in the same

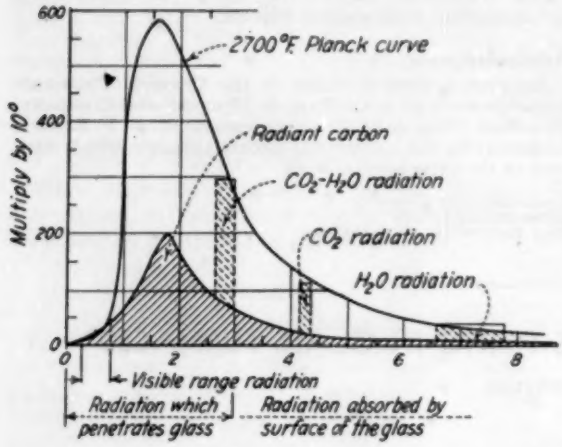

FIG. 1.—Available radiation from a luminous gas flame. U-wave length = 1/1000 mm.

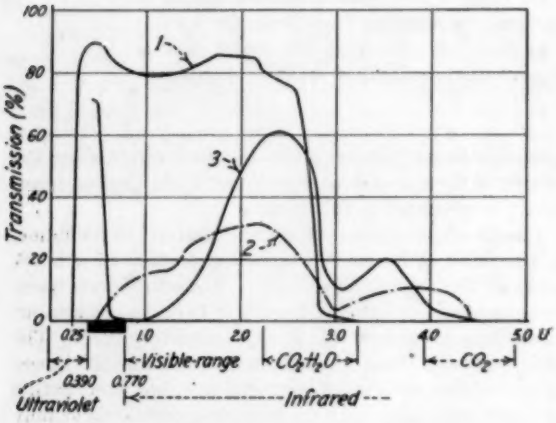

FIG. 2.—Transmission curves for 1/4 in. thickness; (1) ordinary plate glass, (2) amber bottle glass, and (3) cobalt-blue glass. The light source is tungsten, and the filament bulb temperature of the black body is 3000°K.

range that glass has maximum energy transmission values is of importance. No energy transmission data are available for glass in the molten state, but a study of relative glass depths used in actual operating practice brings out some evidence which seems to have a bearing on the subject.

Assuming that molten glass transmission does follow the general trend of the cold glass transmission curves, a method of attacking the problem is to plot the transmission values of Fig. 2 under a 2700°F. Planck curve in terms of radiation transmitted by the glass, as in Fig. 3. The areas under these curves are proportional to the relative amounts of radiant energy transmitted by the glasses in the range from 0.25 to 3 μ, and these values, or areas, are set forth in arbitrary units in Table I.

A survey of a number of amber glass furnaces indicates that a satisfactory working depth for this kind of glass is 20 inches. Assuming then that 20 inches is the proper

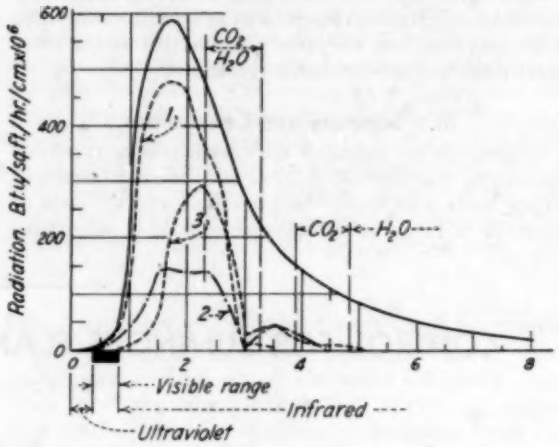

FIG. 3.—2700°F. Planck curve; (1) ordinary plate glass, (2) amber bottle glass, and (3) cobalt-blue glass, 1/4 in. thick.

depth for an amber glass furnace, the corresponding depths for the other glasses may be calculated, using the relative curve areas from the first column of Table I. These calculated values of glass depth are given in the second column of Table I, and it is found that they agree favorably with actual practice, although the actual depths are simply the result of long experience. This close agreement with practice offers quite logical evidence that glasses in the molten state do transmit radiant heat and that a glass subjected to the radiation from a luminous flame should be hotter at a given depth.

TABLE I

Column (1) type of glass; (2) relative areas under curve (Fig. 3) in range 0.25 to 3 μ; (3) relative depths of furnaces (in inches), based on an assumed depth of 20 in. for amber glass

(1)	(2)	(3)
Ordinary plate	3.8	62
Amber bottle glass	1.2	20
Cobalt-blue	1.99	40 1/2

This supposition of higher bottom temperature with the luminous flame has been confirmed by comparing the bottom temperatures of two actual tanks, one of which was fired by a luminous flame and one by a conventional nonluminous flame. These temperatures were taken on the center line of the bottom of the furnaces, 5 feet from the doghouse end, the surface temperature in each case being 2675°F. The furnaces had exactly the same length and width and were working at the same tonnage output, and although the luminous-flame furnace was deeper by 6 inches, its bottom temperature was higher by 190 degrees. There are, of

course, other factors such as increased convection flow that might have contributed to this increase in bottom temperature, but it seems reasonable to suppose that increased flame radiation was also a contributing factor.

Details of the furnaces on which the observations were made are as follows:

Fuel: Natural gas; 100% methane.
Furnace type: Regenerative side port.
Melting end: Width, 13 ft.; length, 15 ft. 4 in.
Tonnage output: Same on both furnaces.
Batch: Same on both furnaces.
Depth of glass: 24 in. with nonluminous flame; 30 in. with luminous flame.

III. Effects of Gas Velocity and Diffusion Rate

It might be assumed from the foregoing data that the problem of the combustion-equipment designer would be the creation of a burner to produce a flame with the greatest emissivity factor. This may be accomplished, as previously mentioned, through retardation of combustion, permitting decomposition of the hydrocarbons in the fuel. Maximum retardation results when the gas and air are made to flow in separate parallel streams with nonturbulent velocities, ranging from 6 to 8 feet per second, a velocity range which does not permit wide variations in the burner capacity.

Most glass furnaces, however, operate with port velocities ranging from 20 to 30 feet per second, and, in order to utilize these turbulent-flow velocities, it is necessary to introduce the fuel and combustion air in individual thick layers. The gas stream must be of such thickness that the retardation of combustion will be sufficient to permit the hydrocarbons in the center portion of the gas stream to dissociate in spite of the turbulent flow. The facility with which luminosity may be obtained with the various commercial fuels is indicated by the respective diffusion coefficients of the various gases (as shown in Table II), bearing in mind that the luminosity is inversely proportional to the diffusion rate.

IV. Flame Length and Its Control

The diffusion coefficients of Table II are also a measure of the flame lengths that may be obtained with the various types of fuel. The length of the flame is inversely proportional to the coefficients of diffusion of the gases making up the fuel. Without some method for controlling the length of a luminous flame, the advantages inherent in its radiation characteristics are offset by the fuel waste resulting from excessive flame length and incomplete combustion. As previously mentioned, the retardation of combustion and some control of velocities are a prerequisite to the formation of a luminous flame. Consideration can now be given to a means for controlling the velocity of a gas stream with respect to an adjacent air stream and an accompanying control of the flame length.

The operation of this method of control may be followed by reference to Fig. 4. Fuel gas is introduced into the port at both sides, the inlet pipes discharging behind a low baffle wall located on the floor and extending across the entire width of the port. This baffle causes the gas to spread itself into a flat stream or layer, underlying the layer of preheated combustion air that flows into the furnace over the top of the baffle wall. It is important that the velocities of the gas and air streams be maintained in fairly close relation to each other. Such a condition could easily be established if port areas would remain fixed, if loads could be kept constant, and if there would be a uniform distribution of preheated combustion air to all ports at all times. From experience, however, it is known that no such conditions exist in the average furnace and certainly not throughout the life of a furnace.

TABLE II

Type of fuel	Sp. gr. air = 1 30 in. Hg at 60°F.	Coefficient of diffusion into air
Coke-oven gas	0.44	1.50
Methane	0.55	1.34
Natural gas	0.61	1.28
Producer gas	0.86	1.08
Blast-furnace gas	1.02	1.02
Industrial propane	1.52	0.81

For satisfactory furnace operation under ordinary conditions, the air supply to the furnace is adjusted to give approximately the correct amount of air to each port. Such an adjustment results in port velocities that are not alike, which renders the velocity-control problem more difficult, because there are a number of variable velocities and the one definite requirement of providing some means for adjusting the gas velocity in each port to correspond to that of each respective overlying air stream.

This velocity adjustment is accomplished by adding a given amount of air to the fuel gas as the gas enters the port. For instance, if 5% of the theoretical air required for the combustion of natural gas were added to the incoming gas, such addition would be equivalent to the introduction of $^1/_2$ cubic foot of air with each cubic foot of fuel gas, resulting in a 50% increase in the velocity of the mixture as it discharges into the port. The control fan shown in Fig. 4 supplies the air for this purpose and, by introducing just the correct amount of control air into the gas stream, it is possible to adjust the velocity of this stream to correspond with the overlying air stream. When furnaces are operated at maximum output, the admixture of air to control the fuel stream velocity not only gives shape to the flame but also aids in increasing the combustion rate on the plane of contact between the gas and combustion air streams In spite of the increased combustion rate, however, the hydrocarbons in the thick stream of fuel gas are permitted to crack, thereby imparting luminosity to the flame.

An exterior view of a window-glass furnace fired with natural gas and utilizing the type of luminous flame control described above is shown in Fig. 5. The piping is shown to be in a dual system, the upper section delivering fuel gas to the ports and the lower section discharging the control air into the fuel pipe before it passes through the port wall. Figure 6 is a view in the same furnace looking into the mouth of the port.

showing the refractory baffle wall and the gas inlet pipes at each end of the baffle.

V. Control of Flame Length at Low Loads

When a furnace is operating under a light load, the fuel input must, of course, be reduced. Then, in order to maintain a flame across the entire furnace hearth, it is necessary that the smaller amount of fuel now being introduced have its combustion rate retarded. This may be accomplished by replacing part of the control air, introduced into the fuel gas stream, by an equal volume of inert gases. Adjustable louvers on the inlet of the control fan permit the substitution of an equal volume of waste gas from the flue for each volume of air handled.

When the waste gas is introduced into the fuel-gas stream, a retardation of combustion results, the CO_2 and N_2 in the waste gas affecting the diffusion rate between the fuel-gas mixture and the overlying combustion air stream. For practical purposes, the coefficients of diffusion are expressed in terms of the mass of the diffusing gas which crosses unit area in unit time under unit concentration gradient. The coefficient is proportional to the total pressure of the two gases and roughly proportional to the square of their absolute temperature. The rate of diffusion of gases seems to parallel the values of density, the lighter gases being the most active. The tabulated values of the densities of some of the gases involved will give a fair indication of what effect on the diffusion rate of a fuel gas may be expected from the admixture of CO_2 and N_2.

TABLE III

DENSITY OF VARIOUS GASES AT 60°F., 30 IN. HG

	(Lb./cu. ft.)
H_2	0.00530
CH_4	0.0421
H_2O	0.0473
C_2H_4	0.0737
C_3H_6	0.0790
CO	0.0734
N_2	0.0737
CO_2	0.1156

(1) Limits of Inflammability

The admixture of waste gas to the fuel gas stream also affects the limits of inflammability of the resulting mixture. This acts to retard further the rate of combustion and thus increase the length of the flame.

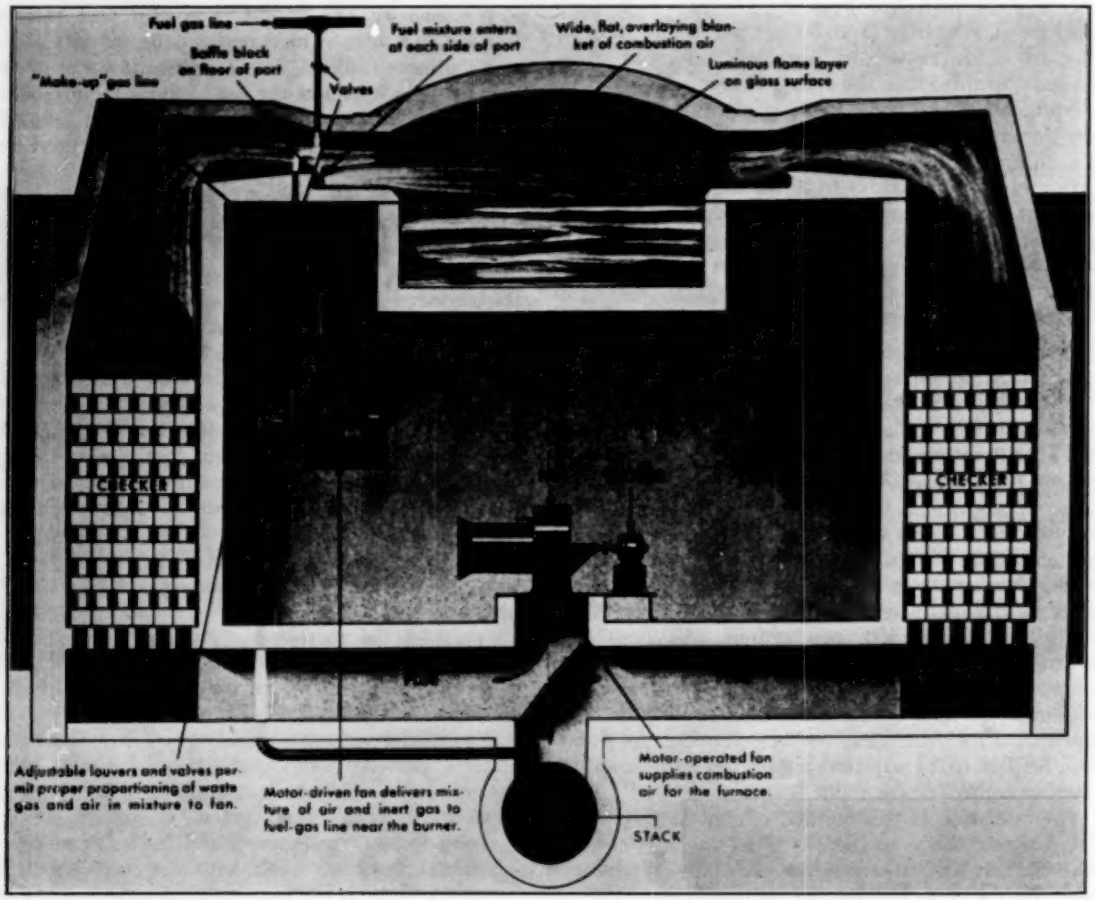
Fuel gas line
Baffle block on floor of port
"Make-up" gas line
Valves
Fuel mixture enters at each side of port
Wide, flat, overlaying blanket of combustion air
Luminous flame layer on glass surface
CHECKER
CHECKER
Adjustable louvers and valves permit proper proportioning of waste gas and air in mixture to fan.
Motor-driven fan delivers mixture of air and inert gas to fuel-gas line near the burner.
Motor-operated fan supplies combustion air for the furnace.
STACK

FIG. 4.—Diagram showing essential features of the luminous flame system.

The composition of Oil City (Pennsylvania) natural gas is assumed to be CH_4 64.3, C_2H_6 32.4, and N_2 3.3; and its heating value, 1239 B.t.u. Based on a theoretical requirement of 11.53 cu.ft. of air per cubic foot of gas, the products of combustion with 20% of excess air are as follows: CO_2 6.42; H_2O 16.02; N_2 72.74; and O_2 4.82. Now the upper and lower limits of inflammability of the natural gas are calculated before and after adding 0.35 volume of waste gas at 60°F. to one volume of natural gas at the same temperature.

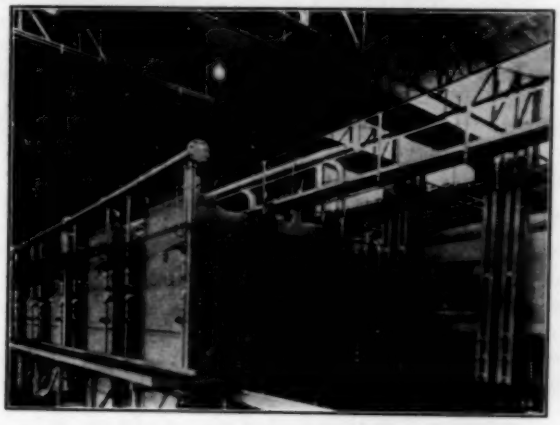

FIG. 5.—Exterior view of window-glass furnace fired with natural gas and using luminous flame control.

The Le Chatelier formula is used to calculate the limit mixtures of the two gases, namely, natural gas with and without an admixture of inert gases. If a, b, and c are the relative proportions of combustible components and A, B, C are their respective limits of inflammability, L, the limit for the mixture, will be

$$L = \frac{a + b + c}{\frac{a}{A} + \frac{b}{B} + \frac{c}{C}}.$$

Using the upper and lower limits of inflammability of various gases as given by the Bureau of Mines,[1] it is found after calculation that the percentage of gas in a mixture of gas and air that will support combustion is a lower limit of 4.16% and an upper limit of 13.4%.

The limits of inflammability of the fuel gas with an admixture of waste gas are now calculated. Everything in the analysis of the mixture except CH_4 and C_2H_6 will be considered as N_2. Both CO_2 and H_2O have combustion retardation properties similar to that of N_2. Oxygen is present in a negligible amount and is disregarded. The concentration of equivalent N_2 per volume of CH_4 and C_2H_6 will be considered as 0.4 with all gases at 60°F.

The inflammability limits of the resultant mixture are found to be a lower limit of 5.8% and an upper limit of 17.0%.

[1] G. W. Jones and R. E. Kennedy, "Inflammability of Mixed Gases: Mixtures of Methane, Hydrogen, and Nitrogen," *Bur. Mines Rept. of Invest.*, No. 3172, 12 pp. (1932); *Ceram. Abs.*, **11** [10] 539 (1932).

By comparing the limits of the fuel gas and mixed gas, it is observed that there has been a decided retardation in the combustion rate of the mixed gas. The spread in limits when set forth in figures indicates that a change of 21.2% has taken place. For example,

$$\frac{(17 - 5.8) - (13.4 - 4.16)}{(13.4 - 4.16)} = 21.2\%.$$

In actual practice, flame length may be increased approximately 25 to 30% through the admixture of waste gases when introduced into the fuel gas in the ratio of $^1/_2$ volume of waste gas per volume of natural gas.

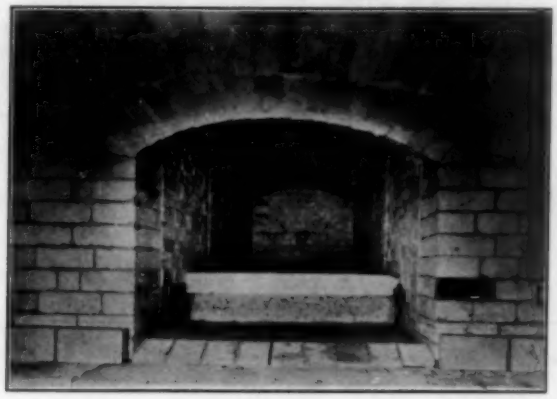

FIG. 6.—Window-glass furnace looking into mouth of port. Note refractory baffle wall and glass inlet pipes at each end of baffle.

VI. Luminous Flame Operation Data

Some of the advantages attributable to the use of luminous flame for glassmelting are listed.

(1) The complete hearth coverage resulting from the use of the luminous flame permits a lower average temperature to be used. Figure 7 shows the glass temperatures existing in a furnace with luminous flame and a furnace with nonluminous flame firing. Note that it was possible to reduce the peak temperature 81°F. and the average temperature 59°F. This furnace, with an inside width of 26 feet, showed a difference in temperature of 15°F. in its width. The temperature of the glass is approximately 15 degrees higher on the side of the furnace exiting the products of combustion.

(2) The crown temperatures on luminous flame-fired furnaces run approximately 300°F. lower than nonluminous flame-fired furnaces, owing to an almost

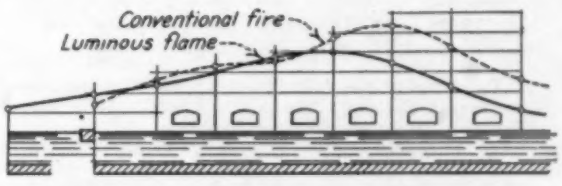

FIG. 7.—81°F. lower peak temp.; 59°F. lower average temp.; 13.7% greater production per unit area.

complete absence of flame coming into contact with the crown.

(3) A luminous flame fire is easily adjusted because it has luminosity and its length may, therefore, be controlled to effect complete combustion within the furnace.

(4) Because of uniformity of operation, luminous flame-fired furnaces produce glass uniform in color. The effect of such a flame on the amount of decolorizer required has been varied. One plant reduced the quantity of decolorizer in the ratio of 32 to 19, or a 40% reduction. Another plant, making the same type of glass but operating its furnace at a 30% greater output per unit area, advised that a slight increase was required in the amount of decolorizer used.

(5) Uniform controlled heating is possible over the entire surface of the glass. Temperatures are easily established and maintained. All of these factors contribute to the melting of a homogeneous cord-free glass.

(6) The complete uniform coverage of the melting area and controlled heat distribution maintains a uniform foam line.

NOTE: References suggested by the author are (1) Glastechnische Tabellen, pp. 462–64. Ed. by W. Eitel, M. Pirani, and K. Scheel. Julius Springer, Berlin, 1932. 714 pp.; *Ceram. Abs.*, **11** [4] 241 (1932); and (2) International Critical Tables, Vol. V, pp. 237–42 (1920); p. 241.

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WET-PROCESS LEADLESS CAST-IRON ENAMELS*

BY B. NIKLEWSKI, JR., AND A. I. ANDREWS

ABSTRACT

Variations in the compositions of wet-process, leadless cast-iron enamels were studied in the development of better enamels. The work was initiated in the laboratory and later was transferred to plant production where the enamels were developed to successful operation. The nonsintered ground coat and the colored cover enamel applied directly on the iron were particularly satisfactory.

I. Introduction

As it is desirable to use leadless enamels, this investigation of the development of wet-process, cast-iron enamels was undertaken. In some countries, lead-bearing enamels are prohibited by law, and in others, general practice makes them very unpopular. In America, the trend is definitely away from the use of lead because of industrial hazards.

The problem of this investigation was the development of satisfactory leadless, wet-process cast-iron enamels.

(1) Literature

The literature on leadless, wet-process cast-iron enamels is meager and unsatisfactory and that on wet-process cast-iron enamels in general is not extensive. Because it is only within recent years that the leadless enamels have proved satisfactory, little reliable information is available in the literature.

The modern leadless enamel must have good workability at a low firing temperature (about 1300°F.), but the majority of the compositions that appear in the literature do not give a good finish under such conditions.

In 1913, Staley and Fisher[1] investigated extensively a substitute for lead in cast-iron dry-process enamels. Nine years later, Danielson and Reinecker[2] did considerable work on wet-process cast-iron enamels. They also tried to substitute other compounds for lead, but leadless enamels were not developed.

In 1929, Andrews and Commons[3] developed several wet-process, leadless cast-iron enamels, but they have not yet had a commercial value.

Staley's[4] discussion concerning the substitution of lead oxide by other compounds in dry-process, cast-iron enamels has many important observations which may be applied to the wet process.

Stuckert[5] discussed the compositions of ground-coat and cover-coat enamels for cast iron and gave a triaxial diagram with an area of recommended ground-coat and cover-coat compositions for cast-iron enamels.

Andrews[6] gives a number of compositions of leadless, wet-process cast-iron enamels and discusses the properties of this type of enamel, and Grunwald,[7] Lang,[8]

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* Presented at the Forty-First Annual Meeting, American Ceramic Society, Chicago, Ill., April 18, 1939 (Enamel Division). Received January 10, 1940.

[1] H. F. Staley and G. P. Fisher, "Leadless Enamels," *Trans. Amer. Ceram. Soc.*, **15**, 620–27 (1913).

[2] R. R. Danielson and H. P. Reinecker, "Wet-Process Enamels for Cast Iron," *Jour. Amer. Ceram. Soc.*, **5** [10] 647–69 (1922).

[3] A. I. Andrews and C. H. Commons, "Wet-Process Leadless Cast-Iron Enamels," *ibid.*, **12** [9] 557–65 (1929).

[4] H. F. Staley, "Principles of Enameling: XI, Leadless Enamels for Cast Iron," *Ceram. Age*, **10** [2] 46–48 (1927); *Ceram. Abs.*, **6** [12] 567 (1927).

[5] (*a*) L. Stuckert, "Ground Coats for Cast Iron," *Ceram. Age*, **20** [2] 60–65 (1932); *Ceram. Abs.*, **12** [1] 8 (1933).

(*b*) L. Stuckert, "Cover Coats for Sheet Steel," *Ceram. Age*, **20** [3] 97–100 (1932); p. 98; *Ceram. Abs.*, **12** [1] 8 (1933).

[6] A. I. Andrews, Enamels, pp. 188–91. Twin City Printing Co., Champaign, Ill., 1935; *Ceram. Abs.*, **14** [7] 158 (1935).

[7] I. Grunwald, Chemische Technologie der Emailrohmaterialien, pp. 260–69. Julius Springer, Berlin, 1922.

[8] (*a*) H. Lang, "Enameling Cast Iron by the Wet Method," *Glashütte*, **64** [30] 498–500 (1934); *Ceram. Abs.*, **14** [1] 5 (1935).

(*b*) H. Lang, "Enameling Cast Iron by the Wet Method," *Glashütte*, **65** [1] 8–11 (1935); *Ceram. Abs.*, **14** [9] 210 (1935).

Vielhaber,[9] as well as Karmaus[10] also give several wet-process, leadless cast-iron enamel compositions.

II. Experimental Procedure

Part of this work was done in the laboratory, and it was completed in a plant where many large experimental batches were smelted. The enamels were used later in production and were carefully observed over a period of several weeks. Whenever necessary, corrections were made to produce satisfactory results. More than two hundred different batches were smelted, but the observations and conclusions presented in this paper are given only for those batches for which an explanation is needed.

(1) Weighing

All laboratory enamel batches were weighed in 1800-gram lots to an accuracy of one gram or in 4000-gram lots with the same accuracy, after which they were screened and mixed. Larger batches were weighed in 600-, 800-, and 1000-pound lots to an accuracy of one-half pound. They were then screened and mixed in a mechanical mixer.

(2) Smelting

All small batches were smelted in refractory crucibles in gas-fired furnaces which were large enough for one pot. Larger batches were smelted in a box-type smelter, and the white enamel batches were smelted in a rotary furnace.

(3) Grinding

The frits of the small batches were ground in small ball mills for four hours, and the slips were brought to the proper consistency. The frits of the larger batches were ground in small 50-pound mills, the colored enamels to a fineness of 3 to 4 grams on a No. 200 screen and the white enamels to a fineness of 6 to 7 grams on a No. 200 screen from 50 cc. of slip. When satisfactory results were obtained, the frits were ground in a 400-pound production mill. For colored enamels applied directly on the iron, five parts of powdered clay to 100 parts of frit were used. This particular clay did not give any opacity to the enamel. For white enamels applied over a ground coat, six parts of Vallendar clay to 100 parts of frit were used. As a rust inhibitor, $^1/_8$ of 1% of sodium nitrite was used in the enamels applied directly on the iron. For the white cover enamels, magnesium carbonate was used as the electrolyte.

Minpro feldspar of the following composition was used in all of this experimental work:

	(%)		(%)
SiO_2	69.04	MgO	0.01
Al_2O_3	17.78	K_2O	8.79
Fe_2O_3	0.11	Na_2O	3.44
CaO	0.58	Ignition loss	0.30

[9] L. Vielhaber, "Development of Leadless Enamels," *Emaillerie*, **4** [8] 9–12 (1936); *Ceram. Abs.*, **16** [8] 236 (1937).

[10] H. J. Karmaus, "Das Emaillieren von Sanitätsgegenständen," *Sprechsaal*, **68** [6] 81–84 (1935); *Ceram. Abs.*, **15** [11] 326 (1936).

(4) Application and Firing

Enamels were sprayed on light castings of different shapes and were fired in an experimental furnace or in a box-type production furnace. Larger experimental loads of castings, weighing between 800 and 1000 pounds, were fired in the furnace from 45 to 60 minutes at temperatures ranging from 1360° to 1400°F.

III. Cover Enamels Applied Without Ground Coat

The greater part of this research was done in developing a good clear frit for colors which could be applied directly on iron. This enamel was designed for use in dark colors, particularly for black and for graining purposes. For this reason, it was necessary that the frit be very clear, that it have a good firing range, and that it be able to withstand refiring as the graining finish was applied over this first coat. During the second firing, the enamel tends to fire off on sharp corners and on rough iron.

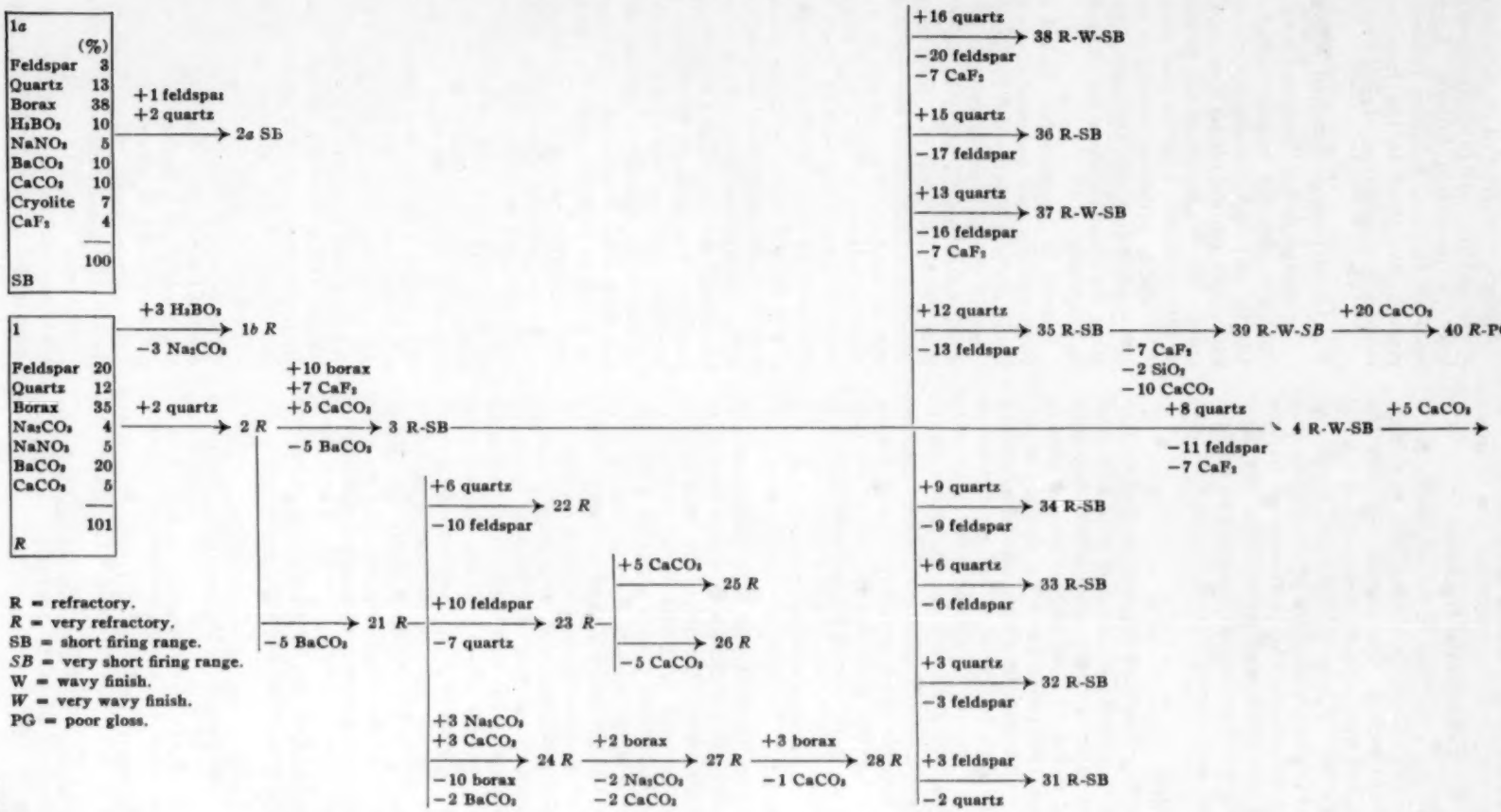
Enamel 1*a* (diagram No. 1) had a nice gloss and finish and was used commercially in an enamel plant. It did not give a very good black color, however, because of the presence of cryolite in the composition which contributed a slight opacity, thus interfering with the development of a good black. Another disadvantage of this enamel was that it did not stand up well in refiring. This enamel is a little too fluid. Fluidity, however, in this type of enamel is a necessary property because the bubbles which develop must be eliminated by a high mobility at the firing temperature. It was thought that it might be possible to develop a type of enamel which would not produce bubbles during firing. In this case, it would not be necessary to have the enamel very fluid, and a wide firing range would be possible. The presence of fluorine compounds and zinc oxide was observed to be a source of bubbles, and for this reason experiments were started with an enamel free from these compounds. The first series, Nos. 1, 1*b*, 2, and 21 to 28 (diagram No. 1 and Table I), shows that this type of enamel is very refractory.

Because previous observations showed that calcium oxide increased the firing range of enamels, five parts of calcium carbonate were substituted for five parts of barium carbonate in enamel No. 2. Ten parts of borax and seven parts of fluorspar were added to make it more fusible. In this way enamel No. 3 was formed, which was used as a basis for a series with variations in the quartz and feldspar contents. The enamels high in quartz had a slightly wavy finish; enamels high in feldspar had a tendency toward scumming, probably due to the presence of high percentages of barium oxide and calcium oxide. The best proportion of quartz to feldspar was chosen to be 22 parts of quartz to 9 of feldspar. Again, it was attempted to make an enamel without fluorine, Nos. 4, 5, and 6 being used; enamels No. 5 and No. 6 were large batches. Several hundred pounds of cast iron were enameled and fired at 1380°F. The resulting enamel was nice looking but was a little too refractory, and the firing range was still quite short.

In enamels Nos. 51 to 54 and 61 and 62 (diagram No. 1), it was found that a decreased amount of sodium oxide tended to increase the firing range of the enamel.

Diagram No. I

Cover Enamels Applied Without a Ground Coat



R = refractory.
R = very refractory.
SB = short firing range.
SB = very short firing range.
W = wavy finish.
W = very wavy finish.
PG = poor gloss.

+2 BaCO3
61 R-SB
+5 BaCO3
62 R-SB
−1 feldspar
−4 quartz
−5 borax
−0.5 Na2CO3
−1 feldspar
−3 SiO2
−1.5 Na2CO3
+16.5 H3BO3
+5 CaF2
+7 ZnO
+3 CaF2
7 R-SB
8 W
+10 borax
9 W
10 W
+1 quartz
11 W
+8 borax
−5.2 H3BO3
−1 BaCO3
−1 CaCO3
−1 feldspar
−4 quartz
−25 borax
−1 NaNO3
−4 Na2CO3
−6.5 H3BO3
−2 quartz
5 R-W-SB
6 R-W-SB
−2 feldspar
−2 quartz
−3 CaCO3
+1 quartz
+5 CaF2
+7 ZnO
+2 CaCO3
52 PG-R
54 W
−10 BaCO3
+10 BaCO3
+10 H3BO3
51 R-PG
−1 NaNO3
−15 borax
−3 feldspar
−7 quartz
53 PG
−8 feldspar
−9 quartz
+0.7 quartz
+1.3 H3BO3
−1.2 CaCO3
121 W
12
13 SB
+5 quartz
14 SB
−5 ZnO
−6 CaCO3
−6 feldspar
+4.2 quartz
+3.9 H3BO3
+4 Na2AlF6
131 SB
−6 feldspar
−6 borax
+2 B2O3
142 W
−2 Na2O
+1 B2O3
15 W
+1 B2O3
16 W
+0.5 Na2O
17 W
+3 ZnO
18 W
19 W
−1 quartz
−1 ZnO
−1 Na2O
−1 B2O3
−2 SiO2
+0.5 Na2O
141 SB
20
(%)
Quartz 26.8
Borax 56.1
H3BO3 7.0
NaNO3 5.0
BaCO3 20.8
ZnO 5.0
CaCO3 7.5
CaF2 11.8

(1940)

and in the absence of fluorine, it was difficult to make an enamel with good workability. If the amount of refractory compounds present was decreased, the enamel was softer but it had a greasy finish.

The addition of three parts of fluorspar to enamel No. 6 formed enamel No. 7, which had a better workability than No. 6, but it still had a short firing range.

To improve these properties, enamel No. 8 was formed by decreasing the amount of sodium oxide present. In order to keep the enamel at the same firing temperature, the amount of refractories was also reduced. Fluorspar was increased, and zinc oxide was added.

In enamel No. 8, the sodium oxide was decreased too much; in enamel No. 9, the amount of sodium oxide was increased slightly, but this enamel was too hard. In enamel No. 10, the quartz was decreased by two parts, and in enamel No. 11, it was increased by one part. One part of barium carbonate and one part of calcium carbonate were also omitted in enamel No. 11.

Enamels Nos. 10 and 11 were used in production, but they were still a little too wavy, and it was necessary to add more sodium oxide.

This change gave enamel No. 12, which was fired at 1360°F. and was used in production for several months. It was used to produce a walnut color with graining decoration, but the gloss was not very high and it was not very good for black colors.

In enamel No. 13, zinc oxide and calcium oxide were reduced; in enamel No. 14, six parts of feldspar were replaced by five parts of quartz, which improved the gloss a great deal.

Enamels Nos. 14, 141, 142, 15, 16, and 17 (diagram No. 1 and Table II) form a series based on the relation between sodium oxide and boron trioxide. In this type of enamel, the relation between the sodium oxide and boron trioxide is very important. Enamels high in boron trioxide have a good firing range and increased viscosity which prevents the crystallization of other compounds, but they have a tendency toward a wavy finish. Enamels high in sodium oxide had a nice gloss and smooth finish, but the firing range was short, they were easily overfired on sharp corners, and they did not cover rough castings well.

Enamel No. 17 was a little too hard, and for this reason three parts of zinc oxide were added to form enamel No. 18. In enamel No. 19, the amount of quartz was decreased by two parts. In enamel No. 20, one part of quartz and one part of zinc oxide were eliminated.

Enamels Nos. 16 to 20 were used in production, but enamel No. 20, which was fired at about 1360°F., gave the best results.

(1) Summary on Cover Enamels Without Ground Coat

The findings on cover enamels, which were applied without a ground coat, may be summarized as follows:

(1) Leadless cast-iron enamels applied directly on the iron must be high in boron trioxide. The amount of boron trioxide which can be used in the enamel is limited by the development of a wavy finish. Enamels low in boron trioxide have a short firing range, are easily overfired on sharp corners, and have a tendency toward scumming.

(2) This type of enamel should be as low in sodium oxide as is possible. The amount is limited by the fact that the enamels too low in sodium oxide are too refractory and those too high in sodium oxide have a short firing range.

(3) The presence of a high percentage of barium oxide, zinc oxide, and calcium oxide has a good influence on the firing range of this enamel, but the amount is limited by the tendency toward crystallization. Of these three compounds, zinc oxide crystallizes most easily and is also the strongest flux. Barium oxide has little influence on the firing temperature. Calcium oxide is a refractory in this enamel.

(4) Feldspar did not have a good influence on this enamel because its presence promoted the crystallization of certain compounds, especially zinc oxide.

(5) Cryolite contributed a little opacity which was undesirable for black colors.

(6) Fluorspar is necessary for good workability, and a small amount greatly increased the fluidity of the enamel. Additions of more than 11%, based on the melted composition, have very little or no influence on the workability.

IV. Ground Coat

One of the oldest types of ground coat for wet-process cast iron is a sintered ground coat. This type of ground coat is not smelted to the glassy state and quenched like a regular frit but is only sintered. It has good adherence, but the big lumps, which are

TABLE I

COVER ENAMELS APPLIED WITHOUT A GROUND COAT

	Enamel No																			
	1	2	3	31	32	33	34	35	36	4	5	6	7	8	9	10	11	12	13	14
Feldspar	20.0	20.0	20.0	23.0	17.0	14.0	11.0	7.0	3.0	9.0	9.0	7.0	7.0	6.0	6.0	6.0	6.0	6.0	6.0	
Quartz	12.0	14.0	14.0	12.0	17.0	20.0	23.0	26.0	29.0	22.0	22.0	20.0	20.0	16.0	16.0	14.0	15.0	15.0	15.0	20.0
Borax	35.0	35.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	20.0	30.0	30.0	30.0	38.0	38.0	38.0
H_3BO_3														16.5	10.0	10.0	10.0	4.8	4.8	4.8
Na_2CO_3	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0							
$NaNO_3$	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
$BaCO_3$	20.0	20.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	14.0	14.0	14.0	14.0
$CaCO_3$	5.0	5.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	15.0	12.0	12.0	12.0	12.0	12.0	11.0	11.0	5.0	5.0
ZnO														7.0	7.0	7.0	7.0	7.0	2.0	2.0
CaF_2			7.0	7.0	7.0	7.0	7.0	7.0	7.0				3.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0

formed in the smelter, make it difficult to quench and to grind. For this reason, it was desirable to develop a ground coat which could be smelted like a normal frit. This new type of ground coat would require large amounts of mill additions. Fluorspar is a valuable compound that improves the adherence of the enamel to the iron, but it is a source of bubbles during firing. A ground coat with a frit content of fluorspar boils easily. To make a good ground coat with a frit containing fluorspar, it is necessary to use a very large amount of mill additions or to make a very refractory frit.

On this principle, ground coat C–1 (diagram No. 2) was developed. This frit did not have strong enough adherence, and it was decided to develop a less refractory frit without fluorspar in an attempt to develop better adherence.

In the previous series of clear frits for colors on cast iron, some enamels were made without fluorine compounds. These enamels were tried with large amounts of mill additions to make a ground coat. Of these, frit No. 5 was chosen as the best, and a series was made using different mill additions.

The first series was a study of the variation between feldspar and quartz. A high amount of feldspar in the mill caused poor adherence in the case of an overfired ground coat.

A ground coat with mill additions high in quartz had strong adherence to iron, but if the ground coat was slightly underfired, the bisque of the ground coat was not very strong and the cover coat chipped easily.

The best proportion of feldspar to quartz was chosen to be three parts of feldspar to four parts of quartz.

The series to which clay was added showed that clay

TABLE II

COVER ENAMELS APPLIED WITHOUT A GROUND COAT

	Enamel No.								
	14	141	15	142	16	17	18	19	20
SiO_2	29.8	29.8	29.8	29.8	29.8	29.8	29.8	27.8	26.8
B_2O_3	23.5	23.5	24.5	25.5	25.5	24.5	24.5	24.5	24.5
Na_2O	11.5	12.0	10.5	9.5	10.5	11.0	11.0	11.0	11.0
BaO	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2
ZnO	3.0	3.0	3.0	3.0	3.0	3.0	6.0	6.0	5.0
CaO	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
CaF_2	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8

DIAGRAM NO. 2

GROUND COAT

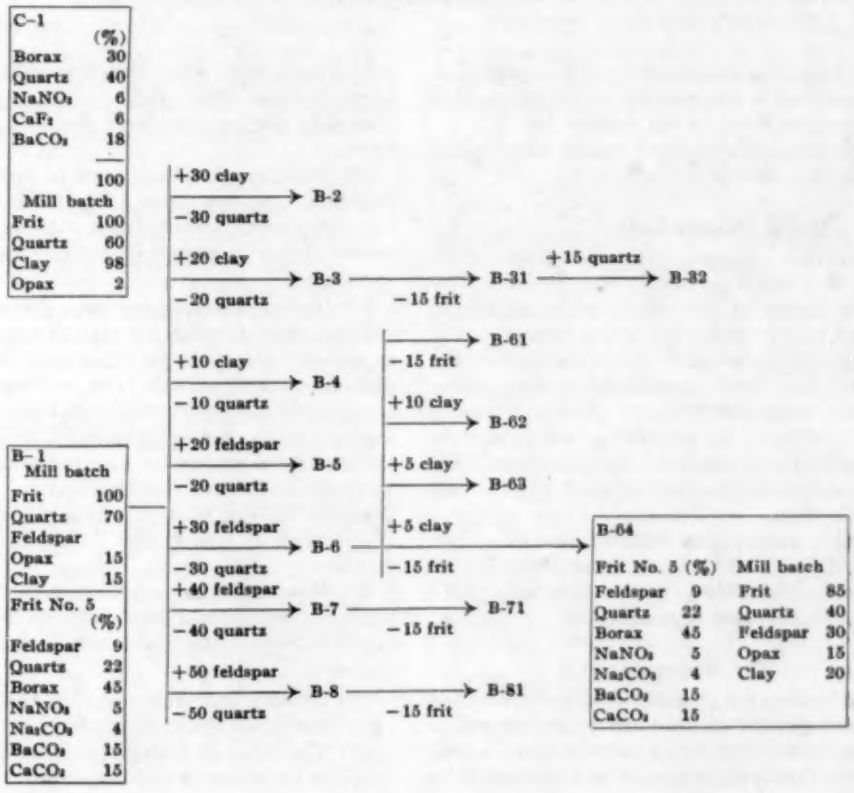
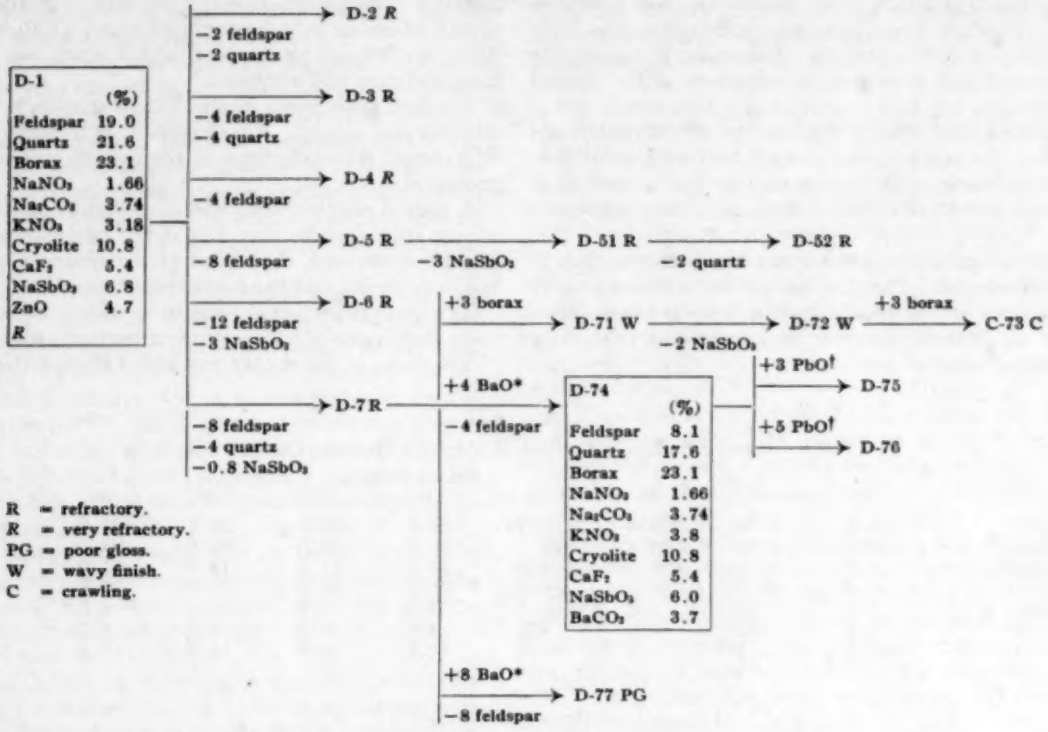


DIAGRAM NO. 3
COVER COAT



* 4 and 8% of barium oxide were substituted for 4 and 8% of feldspar on basis of melted composition.
† 3 and 5 parts of PbO on basis of 100 melted composition.

had a good influence on the properties of a ground coat, but the amount that it was possible to use was limited by the spraying properties of the enamel slip.

The best ground coat developed was B–64 (diagram No. 2), and this was used in production.

V. Cover Coat

The composition of one commercial, white sheet-steel enamel, D–1 (diagram No. 3), was used as a basis for the development of a leadless, white cover-coat enamel for cast iron to be applied over a ground coat.

This enamel was obtained by decreasing the refractory content of sheet-steel enamels and by the substitution of barium oxide for feldspar. The additions of more than 3% of borax led to crawling and further decrease of refractories caused crystallization. The firing temperature of the best enamel (D–74) was 1320°F.

To make an enamel which could be fired at a lower temperature, 3 to 5% of lead oxide was added. With 5% of lead oxide, the enamel could be fired at 1280°F., and this enamel was used in production.

VI. Summary

(1) A good leadless frit (No. 20) was developed which may be applied directly as a colored enamel on iron.

(2) It was found that boron trioxide gave a wide firing range to this type of enamel and prevented the crystallization of other compounds. The amount of boron trioxide that could be added, however, was limited by the fact that large amounts produce a wavy finish.

(3) Increases in sodium oxide in this type of enamel decreased the firing range. The ratio of boron trioxide to sodium oxide should be as high as possible in the enamel, but it is limited by the tendency to produce a wavy finish.

(4) High amounts of barium oxide, zinc oxide, and calcium oxide permitted a high ratio of boron trioxide to sodium oxide, and for this reason these compounds played an important role in enamel composition. The amounts of these compounds that could be used were limited by a tendency toward crystallization. Of these three compounds, zinc oxide had the greatest tendency to induce crystallization and was the strongest flux. Barium oxide had little influence on the firing temperature of this enamel. Calcium oxide was a refractory.

(5) Fluorspar was necessary to produce good workability in this enamel, but additions of more than 11% (melted composition) did not further improve this property.

(6) Cryolite was undesirable in this enamel because of its tendency to produce opacity.

(7) The ratio of feldspar to quartz should be very small or the enamel should be without feldspar. Feld-

spar, however, aided the crystallization of other compounds.

(8) A good leadless ground coat for wet-process cast-iron enamel was developed. The best ratio of feldspar to quartz in the mill additions was found to be three parts of feldspar to four parts of quartz. The amount of clay should be kept high, but the spraying properties of the slip must be considered.

(9) A good white leadless cover coat was developed which may be applied by the wet process over a ground coat on cast iron.

A portion of the data in this paper was obtained in the preparation of a thesis to satisfy in part the requirements for the Degree of Master of Science in Ceramics in the Graduate School of the University of Illinois.

Acknowledgment

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NOTE ON CONE DEFORMATION STUDY IN PART OF THE SYSTEM CALCIUM OXIDE–IRON OXIDE*

By Kenneth Rees and H. G. Fisk†

Abstract

A series of cones prepared from dicalcium ferrite and ferric oxide was fired under oxidizing conditions. The cone of composition 60% dicalcium ferrite plus 40% ferric oxide consistently showed the lowest deformation temperature (2185°F.). According to the phase diagram for the system, the eutectic should be at about 20% dicalcium ferrite and 80% iron oxide (weight per cent). A possible explanation for the difference observed may be that liquids approaching the composition of monocalcium ferrite exhibit a lower viscosity than liquids formed at the eutectic.

According to the equilibrium diagram of Sosman and Merwin[1] for the system CaO–Fe_2O_3, a eutectic is indicated at about 8.0% calcium oxide by weight. Recent work of White, Graham, and Hay[2] has confirmed the approximate composition of this eutectic, for their diagram places the eutectic at 10.0% calcium oxide. Both of these investigators report that, under oxidizing conditions of heating, iron oxide (Fe_2O_3) becomes partially reduced in this system, particularly in compositions high in iron-oxide content, and that the equilibrium relationships therefore cannot be accurately expressed in terms of a two-component diagram. This behavior of iron oxide, that is, its tendency to become reduced at high temperature, was observed by Fisk and McCaughey[3] in a study of the system magnesium oxide–iron oxide.

During the progress of some experiments in the system calcium oxide–iron oxide, a series of cones was submitted to cone deformation tests. Dicalcium ferrite was first synthesized from c.p. calcium carbonate and c.p. ferric oxide, the purity of the product being confirmed by analysis for ferric oxide and by petrographic examination.

Fig. 1.—Cone deformation study of system calcium oxide–iron oxide; cones fired to 2185°F; compositions of cones (*left to right*), Fe_2O_3 (%), respectively: 58.7, 67.0, 75.2, 83.5, 91.7, and 100; C_2F (%) 100, 80, 60, 40, 20, and 0.

Mixtures of the dicalcium ferrite plus ferric oxide were weighed at 20% intervals, bonded with dextrin solution, and pressed to form cones. The cones were heated in a gas-fired muffle furnace under oxidizing conditions. It was found that the cone prepared from 60% dicalcium ferrite and 40% ferric oxide consistently showed the lowest cone deformation temperature in the system. This temperature was found to be 2185°F. by using a base metal thermocouple which had been calibrated at the freezing point of copper melted in a graphite crucible. In a subsequent experiment, a series of cones at 5% weight intervals confirmed the composition of the cone deforming at the lowest tem-

* Received January 29, 1940.

† Mr. Rees is a graduate assistant and Dr. Fisk is director of the Ceramics and Non-Metals Division, Research Foundation of Armour Institute of Technology, Chicago, Ill.

[1] R. B. Sosman and H. E. Merwin, "Preliminary Report on System Lime–Ferric Oxide," *Jour. Wash. Acad. Sci.*, **6**, 532–37 (1916).

[2] J. White, R. Graham, and R. Hay, "Investigation into Oxidizing Power of Basic Slag: I, Determination of Binary Diagram CaO–Fe_2O_3; II, Determination of Dissociation Pressures of Fe_2O_3, $CaO \cdot Fe_2O_3$, and $2CaO \cdot Fe_2O_3$," *Jour. Iron & Steel Inst.* [London], **131** [I] 91–113 (1935); *Ceram. Abs.*, **16** [4] 134 (1937).

[3] H. G. Fisk and W. J. McCaughey, "Equilibrium Studies in Systems Containing Magnesium Oxide, Iron Oxide, and Magnesium Aluminate," *Ohio State Univ. Eng. Expt. Sta. Bull.*, No. 70, 44 pp. (1932); pp. 15–16; *Ceram. Abs.*, **12** [3] 128 (1933).

perature. An analysis of the sintered batch from which this cone was prepared showed it to contain 74.9% ferric oxide when the iron was calculated as ferric oxide. This composition corresponds closely to that of monocalcium ferrite. An analysis of a deformed cone of this composition after slow cooling showed only a trace of ferrous iron present, indicating that any ferrous iron existing at high temperatures had become oxidized on slow cooling.

Figure 1 shows the condition of six cones heated together to the deformation temperature of the 60% dicalcium ferrite-40% iron oxide cone.

From the diagrams referred to, one would expect a cone further toward the iron-oxide side of the diagram to deform at the lowest temperature. The result obtained does not necessarily indicate that the location of the eutectic between monocalcium ferrite and iron oxide on the diagram is in error, but it may be due to an extremely low viscosity for liquids approaching monocalcium ferrite in composition. The ease with which these compositions tend to crystallize would seem to be in accord with this view. Other investigators have observed that frequently there are apparent discrepancies between cone deformation results and minima on equilibrium diagrams.

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June, 1940
19—6

Abrasives

Advanced technique in polishing. J. F. SIEFEN. *Monthly Rev. Amer. Electroplaters' Soc.*, **26**, 455 (June, 1939).—Nuglu, a liquid adhesive used cold for holding abrasive grain on polishing wheels, is compared with hide glue and silicate base adhesives. Advantages of Nuglu include (1) fast cutting without deep scratching, (2) no softening under heat, (3) reduction in number of operations in the grinding and polishing sequence because many intermediate grain sizes may be dispensed with, and (4) use of final grain size without grease or oil which simplifies subsequent operations. See "Nuglu . . . ," *Ceram. Abs.*, **17** [8] 268 (1938). C.H.L.

Application of polishing and buffing wheels: I. ROBERT T. KENT. *Metal Cleaning & Finishing*, **10** [6] 432–40; [7] 502–10 (1938).—K. discusses flat surfaces and describes the finishing of a flat iron soleplate which requires a hard wheel, the regulation of wheel pressure, and special attention to the relative motion of the wheel and the work. The polishing of interrupted flat surfaces, e.g., an open-end wrench, is discussed. A cup-shaped wheel is used for a perfect finish. The blades of an ice skate are used to illustrate the simultaneous polishing of two flat surfaces. Horizontal wheels, free to move sideways, strip the skate accurately and rapidly. **II.** *Ibid.*, [8] 254–66.—Curved surfaces are discussed. Plain cylindrical surfaces are polished best with the axes of the work and wheel parallel. Long, thin cylindrical work is often polished by holding it at an angle to the wheel and feeding it downward. A concave wheel is advantageous for cylindrical work. For conical surfaces the axes of work and wheel are not parallel. The polishing of contoured surfaces brings in many different forms. The polishing of an automobile bumper is discussed in detail. The ironing machine shoe is also discussed. In this, a convex faced wheel with the same radius as the shoe is used. A similar device is described for polishing tire covers. **III.** *Ibid.*, [9] 626–32, 641.—The principles of selecting the proper wheel for satisfactory work and the various materials which have been used are described. The Clothflex wheel and its field of application are presented in detail. The compressed wheel is described and its field of application is discussed. A table of application is given for the compressed wheel. Polishing wheel speeds are also considered. **IV.** *Ibid.*, [10] 694–704.—The subject of buffs is considered. There are four general classes: (1) full disk buffs, (2) sewed-piece buffs, (3) folded buffs, and (4) buffs made of continuous strips of cloth. The specifications and types of each are discussed fully. The methods of sewing the material for various types of buffing are presented. The horsepower required and buffing applications are considered. **V.** *Ibid.*, [11] 763–75.—Polishing and buffing machines are discussed in general, and the hand lathe is described in detail. Semi-automatic and automatic machines for both polishing and buffing are divided into three general classes: (1) straight-line machines, (2) multiple-head machines, and (3) contour machines. Part of a paper by K. (*Ceram. Abs.*, **10** [2] 85 (1931)) is summarized in six sections. The straight-line, multiple-head, and contour machines are illustrated and described in detail. The economics of buffing and polishing machines are considered. F.F.

Carborundum Company. ANON. *Ind. Marketing*, **23** [4] 16–19 (1938).—The organization setup, various divisions and plants, business policies, sales promotion, and advertising efforts are described. The abrasives division which manufactures Carborundum (silicon carbide) and Aloxite (crystalline alumina), the refractory division which manufactures Carbofrax, the division making porous filtration media, and their marketing organization are outlined. Advertising comprises sales literature, displays, advertisements in 47 business and 6 consumer publications, motion pictures, and, most effective of all, a radio program. F.E.S.

Determination of carbon in boron carbide by the combustion method. I. G. SHAFRAN AND R. R. VLADIMIRSKAYA. *Zavodskaya Lab.*, **7**, 269–72 (1938).—Carbon can be determined in boron carbide with an accuracy of 0.2 to 0.5% in the Wirts-Strohlein apparatus by igniting a 0.05- to 0.06-gm. sample under a cover of 1 gm. of Pb filings in

a porcelain boat in a combustion tube and an O current at 1000° to 100° for 10 to 20 min. P.B. & E.S.

Grinding wheels of "noble corundum" as universal grinding wheels. F. KÜLPMANN. *Oberflächentech.*, **17** [4] 23–24(1940).—Noble corundum is a corundum of at least 99% Al_2O_3; ordinary corundum has a purity of 95 to 97% Al_2O_3. In general, Al_2O_3 grinding wheels are less sensitive in the firing process than silicon carbide wheels and are much more resistant than the latter because of the brittleness of SiC. The binders used for 99% wheels are specially made, are rich in clay, and combine the properties of SiC and Al_2O_3. The 99% corundum is tougher than the lower grade. No fine-grained additions are required in the binder. Such wheels can be used for grinding hardened and unhardened tool steels, high-speed steels, annealed and unannealed malleable castings, Ni-gray iron and hard castings, earthenware, refractories, carbon, Al, and Silumin. The firing temperature of such wheels is only 1230°C. (Seger cone 7); SiC wheels require 1300° to 1350°. Reduced grinding time, longer life, and cheaper manufacturing cost are the economical advantages of noble-corundum wheels. M.H.

Polishing technique for stainless steels. WALTER M. MITCHELL. *Iron Age*, **144** [16] 56–59, 92–94; [17] 32–35, 92 (1939).—Methods and abrasives commonly used for polishing other alloys are generally unsuitable for stainless steel. High-quality mill finishes are not economical for material which is to be subjected to severe forming, deep drawing, or pickling. For the finish of fabricated articles, grinding must be conducted with more than usual care. Solid wheels are used, and those with organic (rubber, Bakelite, etc.) bonding are more efficient than vitrified wheels. As a dry abrasive, material of the fused aluminum oxide type is recommended, and imported Turkish emery is strongly recommended for higher finishes. With all grinding, polishing, and buffing operations, it is desirable to change the direction with each subsequent operation. Polishing wheels of fabric with glue and abrasive are being replaced to some extent by a rubber-cushion type with abrasive (aluminum oxide in 24 to 230 grit) on cloth belts. Buffing materials prepared specifically for stainless steel are compounds of levigated alumina or chromic oxide. The treatment of sheets and plates, etching, and protection of finished surfaces are also dealt with. E.H.McC.

Testing the effectiveness of polishing agents. W. KÖNIG. *Farben-Ztg.*, **44**, 791–93, 817 (1939); *Chem. Abs.*, **33**, 8330 (1939).—The more effective an agent for polishing lacquered or similar surfaces, the greater is the gloss produced per unit of work expended in polishing. A device for measuring the work expended is described in detail; the gloss can be measured photoelectrically. Sample data are given.

SEPARATE PUBLICATION

Abrasive Wheel Manufacture. Technical Control of Dusts. F. F. KRAVATH. *Penna. Dept. Labor & Ind., Safe Practice Bull.*, No. 13, 10 pp. (1939).—K. describes local exhaust arrangements for three processes. Grading screens are enclosed and exhausted. Atmospheric dust caused by removal from hoppers of cloth filters is controlled by a local exhaust hood at the point of discharge. Hoods for grinding wheel dressing machines are like those on ordinary wheels, well enclosed and having local illumination. F.S.M.

PATENTS

Abradant. KARL WOLF AND FRANZ GROM (I. G. Farbenind. A.-G.). U. S. 2,196,135, April 2, 1940 (May 11, 1938).

Abrading element. H. G. BARTLING (Minnesota Mining & Mfg. Co.). U. S. 2,197,629, April 16, 1940 (Oct. 6, 1933); continuation of application Serial No. 413,679, Dec. 12, 1929, and a division of 2,186,001 ("Flexible...," *Ceram. Abs.*, **19** [3] 58 (1940)).

Abrading or sanding machine and method. NORMAN POTASH. U. S. 2,195,340, March 26, 1940 (March 15, 1938).

Abrasive. DONALD E. EDGAR AND HARRY G. STAUFFER (E. I. du Pont de Nemours & Co.). Can. 386,601, Jan. 30, 1940 (Sept. 30, 1937). G.M.H.

Abrasive article. R. C. BENNER AND R. L. MELTON (Carborundum Co.). Can. 387,119, Feb. 27, 1940 (March 11, 1938). G.M.H.

Abrasive material. L. S. WASHBURN (Norton Co.). U. S. 2,196,090, April 2, 1940 (Nov. 29, 1935).—A grinding wheel comprises abrasive grain and a bond including $[(C_3H_8)_2O]_n$.

Abrasive-throwing centrifugal apparatus. St. GEORGES ENGINEERS, LTD., AND F. W. WILSON. Brit. 518,803, March 20, 1940 (Oct. 15, 1938).

Abrasive wheel. M. M. BOUCHER (Behr-Manning Corp.). U. S. 2,197,741, April 16, 1940 (March 2, 1939).

Abrasive wheel. EDWIN T. RAINIER (Dominion Rubber Co., Ltd.). Can. 387,523, March 19, 1940 (Feb. 4, 1938). A. G. SCUTT AND A. L. BALL (Carborundum Co.). Can. 386,463, Jan. 23, 1940 (Feb. 4, 1938). EDWARD VAN DER PYL (Norton Co.). Can. 386,869, Feb. 13, 1940 (Oct. 8, 1937; in U. S. Oct. 9, 1936). G.M.H.

Apparatus for truing surfaces by grinding. BREVETS AERO-MÉCANIQUES SOC. ANON. Brit. 519,146, March 28, 1940 (Aug. 17, 1938).

Article made from powdered mixes and its manufacture. J. A. BOYER (Carborundum Co.). U. S. 2,197,655, April 16, 1940 (July 28, 1936).—The process of forming an abrasive article in which the abrasive is bonded by a metal alloy consisting essentially of a solid solution comprises forming a mix containing abrasive grain and at least two components of the solid solution in finely divided form, one of the components being present in minor proportion and having a melting point substantially lower than the temperature of complete melting of the alloy, sintering the metal powder by applying pressure to the mix, and heating it until the metallic portion of the mix, after passing through a plastic condition in which a portion of the metal is molten, resolidifies to form a compact solid solution alloy firmly holding the abrasive grain, the temperature at all times being below that temperature at which the alloy becomes completely molten.

Automatic cam-grinding machine. H. A. SILVEN (Norton Co.). U. S. 2,194,434, March 19, 1940 (June 2, 1938).

Automatic grinding or abrading machines. NORTON CO. Brit. 518,794, March 20, 1940 (Oct. 4, 1937).

Brake shoe lapping apparatus. D. A. WALLACE (Chrysler Corp.). U. S. 2,195,059, March 26, 1940 (Oct. 25, 1937).

Buffing wheel. J. J. V. ARMSTRONG (Jackson Buff Corp.). Brit. 518,250, March 6, 1940 (Nov. 24, 1938).

Buffing wheel and method of making. H. E. HARGY, SR. U. S. 2,197,661, April 16, 1940 (April 10, 1939).

Crankpin grinder. C. J. COOK. U. S. 2,197,684, April 16, 1940 (May 21, 1938).

Crankshaft lapping machine. D. A. WALLACE AND E. C. LEE (Chrysler Corp.). U. S. 2,195,048, March 26, 1940 (Oct. 24, 1936). U. S. 2,195,058, March 26, 1940 (Oct. 7, 1937; renewed Dec. 28, 1939).

Finishing apparatus and method. D. A. WALLACE (Chrysler Corp.). U. S. 2,195,065, March 26, 1940 (Nov. 5, 1938).

Forming the operative surface of grinding or abrading wheels. COVENTRY GAUGE & TOOL CO., LTD., S. J. HARLEY, AND J. E. WAINWRIGHT. Brit. 519,081, March 28, 1940 (Sept. 21, 1938).

Grinding apparatus. S. G. RICHARDSON (Norton Co.). Can. 386,870, Feb. 13, 1940 (Oct. 13, 1937; in U. S. Oct. 14, 1936). G.M.H.

Grinding machine. F. E. JOHNSON (Norton Co.). Can. 386,988, Feb. 20, 1940 (Oct. 12, 1937; in U. S. Oct. 12, 1936). G.M.H.

Grinding, specially applicable to cams for internal-combustion engines. MAIDSTONE & DISTRICT MOTOR SERVICES, LTD., G. F. FRENCH, AND H. O. HALLAS. Brit. 518,923, March 28, 1940 (Aug. 11, 1938).

Grinding tool. E. M. McGovern and Paul Schrick (Lempco Products, Inc.). U. S. 2,195,493, April 2, 1940 (Dec. 17, 1938).

Grinding wheel. S. S. Kistler and C. E. Barnes (Norton Co.). U. S. 2,195,215, March 26, 1940 (Oct. 23, 1937).—An abrasive body consisting of abrasive grain bonded with an alkyd resin bond comprising a polyhydric alcohol and an acid at least 20% of which is selected from the group consisting of maleic acid and its anhydride and fumaric acid.

Grinding-wheel tool. C. E. Strausbaugh. U. S. 2,194,622, March 26, 1940 (Aug. 18, 1939).

Grinding wheel truing apparatus. C. G. Flygare and C. C. Alvord (Norton Co.). U. S. 2,194,422, March 19, 1940 (Sept. 20, 1938).

Hand-operated blade grinder. Guillaume Barsch. U. S. 2,197,119, April 16, 1940 (Nov. 10, 1937).

Honing machine. George Crompton, Jr., and T. H. Nye (Norton Co.). U. S. 2,194,821, March 26, 1940 (Aug. 19, 1938).

Honing tool. D. A. Wallace (Chrysler Corp.). U. S. 2,195,055, March 26, 1940 (Aug. 21, 1937).

Horizontal honing machine. H. J. Caldwell (Barnes Drill Co.). U. S. 2,194,638, March 26, 1940 (Nov. 19, 1938).

Jig for grinding the cutting edges of drills or other end-boring tools. H. Brook. Brit. 519,143, March 28, 1940 (Sept. 30, 1938).

Lap-grinding compound. C. A. Hochwalt (Monsanto Chemical Co.). U. S. 2,193,965, March 19, 1940 (June 3, 1939).—A lap-grinding compound comprises an abrasive and an alkyl phosphate salt.

Lapping apparatus. D. A. Wallace (Chrysler Corp.). U. S. 2,195,047, March 26, 1940 (July 22, 1936). U. S. 2,195,049, March 26, 1940 (Nov. 16, 1936; renewed Aug. 25, 1939). U. S. 2,195,051 and 2,195,052, March 26, 1940 (Jan. 30, 1937). U. S. 2,195,053, March 26, 1940 (March 15, 1937; renewed July 28, 1939). U. S. 2,195,057, March 26, 1940 (Oct. 7, 1937). U. S. 2,195,061, March 26, 1940 (Jan. 30, 1937; April 27, 1938). U. S. 2,195,063, March 26, 1940 (July 22, 1936; July 1, 1938). D. A. Wallace and E. C. Lee (Chrysler Corp.). U. S. 2,195,054, March 26, 1940 (Aug. 13, 1937). U. S. 2,195,060, March 26, 1940 (Nov. 8, 1937).

Lapping apparatus and method. D. A. Wallace (Chrysler Corp.). U. S. 2,195,056, March 26, 1940 (Sept. 16, 1937; renewed April 26, 1939). U. S. 2,195,062, March 26, 1940 (June 6, 1938). U. S. 2,195,064, March 26, 1940 (Sept. 23, 1938).

Manufacture of abrasive coated sheet material. W. J. Tennant (Carborundum Co.). Brit. 518,833, March 20, 1940 (Sept. 5, 1938).

Manufacture of abrasive products. J. N. Kuzmich (Raybestos-Manhattan, Inc.). U. S. 2,197,552, April 16, 1940 (Dec. 10, 1937).—A cured abrasive product comprises abrasive granules bonded with a cured organic primary bond selected from a group consisting of shellac, rubber, and synthetic resin and with a fused secondary bond, the secondary bond being a material selected from a group consisting of selenium, tellurium, and sulfide compounds thereof.

Method and means for grinding. D. A. Wallace (Chrysler Corp.). U. S. 2,195,050, March 26, 1940 (Dec. 28, 1936).

Multiple-spindle grinding or abrading machines. Bryant Chucking Grinder Co. Brit. 518,914, March 28, 1940 (July 8, 1937).

Oilstones for sharpening edge tools. F. J. Wiggins. Brit. 518,909, March 20, 1940 (April 27, 1939).

Polishing machine. A. O. Andersen. U. S. 2,194,780, March 26, 1940 (Feb. 3, 1939). H. W. Dunbar and H. S. Indge (Norton Co.). U. S. 2,196,108, April 2, 1940 (Aug. 13, 1937).

Portable blade grinder. F. K. Benedict. U. S. 2,193,854, March 19, 1940 (June 10, 1938).

Production of abrasive materials. G. H. Jackson (Carborundum Co.). U. S. 2,194,472, March 26, 1940 (Dec. 30, 1935).—An abrasive article comprises a backing and a coating of abrasive grain held on the backing by an adhesive binder.

Surface-finishing apparatus. D. A. Wallace (Chrysler Corp.). U. S. 2,195,066, March 26, 1940 (April 11, 1939; renewed Jan. 3, 1940).

Track rail grinding apparatus. R. N. Miller (Pennsylvania Railroad Co.). U. S. 2,197,729, April 16, 1940 (Jan. 20, 1938).

Valve seat grinding machine. F. O. Albertson and H. E. Dowling (Albertson & Co., Inc.). U. S. 2,194,062, March 19, 1940 (Feb. 28, 1938).

Art and Archeology

Cap brooches of the Renaissance. Charles R. Beard. *Connoisseur*, **104** [460] 287–93 (1939).—These have their origin in the early practice of wearing leaden pilgrims' signs or nobelmen's latten badges in the hat. Gold, enamels, and jewels were worked into these badges, by such goldsmiths as Cellini, in all of the European countries. Illustrated. M.E.P.

Causes of shrinkage of decalcomania after firing. P. F. Romodan. *Keramika*, **1939**, No. 7, pp. 31–33. P.B. & E.S.

Cycle Club and Jacobite hunts and some commemorative glasses. Francis Buckley. *Connoisseur*, **105** [462] 57–62 (1940).—Various famous hunt clubs rose from political groups in England after 1760, and they continued to use what was known as "Fiat" tableware. The decorative stemware engraved with their mottoes and symbols is very interesting. Illustrated. M.E.P.

Defects of underglaze colors and majolica glazes for whiteware. A. Z. Barabanova and O. V. Tyzhnova. *Keramika*, **1939**, No. 7, pp. 33–36. P.B. & E.S.

Old and new tile. Frank Davis. *Illus. London News*, **104** [2712] 640 (1939).—Colors and tile designs (dating from 1200 to 1700) of flowers, foliage, ships, fabulous beasts, birds, and people are incomparable and inimitable to this day. Freedom of design is lost but precision is gained in the modern tilemaking kiln. Illustrated. L.F.M.

BOOK

Stained Glass of the Middle Ages in England and France. Hugh Arnold. A. & C. Black, Ltd., London. Price 15s. Reviewed in the *Times Lit. Supp.*, No. 1973, p. 690 (1939). —A. presents a study of the stylistic problems confronting the medieval artist. The style of each period is described generally, and the more eminent examples are discussed in detail. The book ends with the late 15th-century glass of Malvern and Fairford. Illustrated with 50 plates in color by Lawrence B. Saint. K.W.W.B.

PATENTS

Designs for:

Bottle. H. R. McDonald (Armstrong Cork Co.). U. S. 119,524, March 19, 1940 (Dec. 7, 1939).

Bottle. Philip Goldman. Can. 12,628, Feb. 16, 1940. MacDonald & Son (Timmins), Ltd. Can. 12,592, Jan. 9, 1940. Procter & Gamble Co. Can. 12,578, Jan. 9, 1940. G.M.H.

Bowl. E. W. Fuerst (Libbey Glass Co.). U. S. 119,587 and 119,614, March 26, 1940 (Jan. 26, 1940). U. S. 119,746, April 2, 1940 (Jan. 26, 1940).

Chinaware. Thos. C. Wild & Sons, Ltd. Can. 12,641, Feb. 16, 1940. G.M.H.

Closet bowl. H. R. Van Sciver (Crane Co.). U. S. 119,871, April 9, 1940 (Sept. 8, 1939).

Comport. E. W. FUERST (Libbey Glass Co.). U. S. 119,586, March 26, 1940 (Jan. 26, 1940). U. S. 119,745 and 119,747, April 2, 1940 (Jan. 26, 1940).

Dish. J. E. SPENCE (Hazel-Atlas Glass Co.). U. S. 119,870, April 9, 1940 (Dec. 19, 1939).

Domestic cooking ware made of earthenware. T. G. GREEN & Co., LTD. Can. 12,596, Jan. 13, 1940. G.M.H.

Electric range. W. J. RUSSELL (Westinghouse Electric & Mfg. Co.). U. S. 119,559, March 19, 1940 (Nov. 15, 1939).

Jar. J. L. HENDRICKSON (Colgate-Palmolive-Peet Co.). U. S. 119,521, March 19, 1940 (Dec. 13, 1939).

Jelly tumbler. W. J. LUNDY (Olean Glass Co.). U. S. 119,862 and 119,863, April 9, 1940 (Jan. 18, 1940).

Pattern for glass tableware of all kinds. LIBBEY GLASS Co. Can. 12,594, Jan. 13, 1940. G.M.H.

Pitcher. P. H. GENTER (Red Wing Potteries, Inc.). U. S. 119,749, April 2, 1940 (June 19, 1939).

Plate. ONNIE MANKKI (Imperial Glass Corp.). U. S. 119,864, April 9, 1940 (Feb. 19, 1940). R. A. MAY (Duncan & Miller Glass Co.). U. S. 119,964, April 16, 1940 (Dec. 21, 1939).

Soda glass. T. C. HEISEY (A. H. Heisey & Co.). U. S. 119,856, April 9, 1940 (Feb. 7, 1940).

Table glassware. CHARLES GURD & Co., LTD. Can. 12,633 to 12,640, Feb. 16, 1940. G.M.H.

Torchère bowl. J. T. SHEERER (Victory Glass, Inc.). U. S. 119,821 and 119,822, April 2, 1940 (Jan. 4, 1940). U. S. 120,022, April 16, 1940 (Jan. 4, 1940).

Tumbler. J. A. HUTCHISON. U. S. 119,754, April 2, 1940 (Jan. 12, 1940).

Vase. E. W. FUERST (Libbey Glass Co.). U. S. 119,615 to 119,621 and 119,703, March 26, 1940 (Jan. 26, 1940). CHARLES SAWYER (Libbey Glass Co.). U. S. 119,642 and 119,643, March 26, 1940 (Jan. 26, 1940).

Cements

Celite: VII, Systems CaO–Al_2O_3–Fe_2O_3 and CaO–Al_2O_3–Fe_2O_3–SiO_2, in which the molar ratio Al_2O_3:Fe_2O_3 is 2 or 4. TOSHIYOSHI YAMAUCHI. *Jour. Japan. Ceram. Assn.*, **46**, 66–76 (1938); *Chem. Zentr.*, **1938, I**, 3515–16; *Chem. Abs.*, **33**, 9574 (1939).—In order to study the solid solutions in the system CaO–Al_2O_3–Fe_2O_3, in which the ratio Al_2O_3:Fe_2O_3 is greater than 1, microscopic and X-ray investigations were made of the minerals occurring in fired mixtures of $x CaO:2Al_2O_3:Fe_2O_3$ and $y CaO:4Al_2O_3:Fe_2O_3$, the values of x being 5, 6, 7, 8, 10, and 15 and those of y being 6, 8, 10, 12, 15, 20, and 30. For values of $x = 5$ or more the solid solutions in the fired products of the first mixture were the same as those previously obtained with the mixture $6CaO:2Al_2O_3:Fe_2O_3$. For the mixture $y CaO:4Al_2O_3:Fe_2O_3$ the miscibility of the solid solutions in the fired products increased with increase in the value of y. For $y = 12$ the miscibility reached its widest limits. The miscibility of the solid solution in this series showing greatest miscibility is greater than that of the solid solution of $6CaO:2Al_2O_3:Fe_2O_3$. In lime-rich mixtures of CaO–Al_2O_3–Fe_2O_3 the addition of SiO_2 has no influence on the composition of the solid solutions of the Fe_2O_3 series obtained by firing the mixture. Correspondingly, it must be correct that in the fired products of lime-rich mixtures of CaO–Al_2O_3–Fe_2O_3–SiO_2 the miscibility of the solid solutions gradually increases with increase of the Al_2O_3:Fe_2O_3 ratio. The maximum miscibility must correspond to a composition of about $6.2CaO:2.2Al_2O_3:Fe_2O_3$. It is therefore to be expected that in lime-rich cements the celite portion changes its composition with change in the Fe modulus, i.e., in lime-rich cements with an Fe modulus of 1.4 and above, the composition of the solid solutions of the Fe_2O_3 series existing in the cement is about $6.2CaO:2.2Al_2O_3:Fe_2O_3$. With decreasing values of the Fe modulus (below 1.4) the miscibility of the solid solutions of the Fe_2O_3 series decreases. For Parts III–V see *Ceram. Abs.*, **18** [3] 86–87 (1939).

Mineral content of aluminous cement. N. SUNDIUS. *Proc. Symposium Chem. Cement, Stockholm*, **1938**, pp. 395–421; abstracted in *Chem. Zentr.*, **1939, II**, 3736.—S. presents a report on the chemical composition and mineral content of four types of aluminous cements. M.V.C.

PATENT

Producing Portland cement. FULLER Co. Brit. 519,018, March 28, 1940 (Dec. 1, 1937).

Enamel

Acid and alkali resistance of some vitreous enamelware. AMANDO CLEMENTE AND LORETO ALZATE. *Univ. Philippines Nat. & Applied Sci. Bull.*, **7**, 51–57 (1939); *Chem. Abs.*, **34**, 866 (1940).—The resistances of commercial samples of Swedish, American, and Japanese enamelware to dilute solutions of citric acid, AcOH, and NaOH were determined.

Cast-iron enameling troubles and practice. GORDON S. LINDSEY. *Enamelist*, **16** [8] 5–9 (1939).—L. briefly discusses cast-iron enameling and some of the troubles associated with it. Practical problems such as defective cast iron, proper abrasive grain for sandblasting, the importance of correct milling and spraying, and controlled drying and firing are discussed. Contamination of enamel by oil or water in the air lines and from other sources may cause trouble in the enameling of cast-iron ware. L.E.T.

Common causes of cover-coat blistering. C. D. CLAWSON. *Enamelist*, **16** [6] 26–28 (1939).—C. discusses blistering of enamel under such terms as viscous blisters, glass-eye boils, isolated blisters, cinders, fly ash, etc. These isolated blisters are generally admitted to be the visual result of an oversized bubble of gas escaping through the surface of the molten cover coat. About 70% of the blisters are caused by impurities and contamination in the ground coat and in the cover coat, and about 30% are caused by steel defects and impurities. Highly viscous acid-resistant enamels will aggravate blistering. It is therefore desirable to select the most fluid enamels available. Hard firing of the half finish coat will minimize blisters. Several other recommendations for the control and elimination of blisters are given. See "Blistering...," *Ceram. Abs.*, **19** [5] 106 (1940). L.E.T.

Enameling troubles. S. W. VICKERY. *Enamelist*, **16** [7] 8–10 (1939).—Ninety per cent of the common enameling troubles are due to a change in material or to shop practice. Troubles that arise can often be traced to (1) improper cleaning of the metal either by pickling or blasting, (2) changes in the spraying or blasting, and (3) changes affecting some small feature in design. Unreliable chemicals and other raw materials are other sources of trouble. Fish scaling, usually defined as a local breakdown of adherence at the point affected, is generally attributed to many causes, but it may be due to the clay, acid, neutralizer, or faults in steel. The nature and elimination of several types of enameling troubles are discussed. L.E.T.

Looking over the porcelain enameler's shoulder. JOSEPH D. WALKER. *Metal Cleaning & Finishing*, **10** [11] 750–58 (1938).—W. stresses the fact that a clean surface is essential to a good enameled product. He discusses the surface preparation procedures of sandblasting: removal of dirt and scale by annealing, chemical cleaning methods and apparatus, pickling, and rinsing of the clean object. F.F.

Modern opacifiers for enamels. HEINRICH KIRST. *Glashütte*, **70** [2] 17–18; [3] 30–32 (1940).—The first group

of opacifiers discussed comprises those whose index of refraction is greater than that of the enamel. They are dispersed crystalline substances in the amorphous enamel and produce the opacifying effect because of the difference in the way the light is refracted by the enamel and the opacifier. To this group belong tin oxide; antimony (five-valent form for food containers); antimony compounds (sodium metantimonate and the less practical metantimonic acid salts of alkaline earths and magnesium); antimony in combination with other opacifiers (alkali salts with the addition of kaolin, feldspar, etc.); zirconium compounds, whose opacifying action is dependent on the addition of other substances, such as silicates, for best results; TiO_2 in very pure preparations with antimonates or as a supplementary addition; cerium oxide in pure form, whose use is conditioned by the process of manufacture and the pretreatment of the oxide; rare earths, especially columbium and tantalum, which give satisfactory results but whose cost of purification is prohibitive; zinc sulfide, a less important white opacifier for enamels; and lead arsenate, a good opacifier for lead glazes but limited because of its toxic nature. The second type of opacifier discussed is the gas opacifier, which may be an organic or inorganic compound. When fused with the enamel, these compounds give off gases, such as steam, carbonic acid, carbon monoxide, oxygen, nitrogen, or fluorides, and leave no visible or injurious residue in the enamel. The evolution of gas must proceed slowly, and the gas bubbles should be a certain size. The finely dispersed gas bubbles formed in the enamel give it the white appearance because the index of refraction of the gas in this case is smaller than that of the enamel and the light is variously refracted and dispersed. Another type of opacifier is the preopacifier, which is added directly to the raw mix and fused with it instead of being later added to the mill as are the opacifiers named above. The most important of these are the fluorine compounds, especially synthetic cryolite and sodium fluosilicate. Phosphate and molybdate opacification is another but less important method. One opacifier is never used alone but is always combined with two or more opacifiers. The use of a suitable preopacifier saves on mill-added opacifiers. The method of manufacture, pretreatment, kinds and quantity of impurities or secondary ingredients, grit fineness, and physical structure condition the use and suitability of an opacifier; it is therefore important to determine what form and combination of materials will yield the best results for the least money, bearing in mind the fact that a more costly opacifier may be cheaper in the long run because it permits the enamel to be applied thin, while enamels containing cheaper opacifiers must be applied thick; thick coats require more materials and are less adherent. M.V.C.

Tearing in cover-coat enamels. P. G. BARTLETT. *Enamelist*, **16** [4] 16–21 (1939).—B. discusses tearing, a comparatively common defect in cover-coat enamels. A number of factors involved, such as mill additions, color oxides, fineness of grinding, spraying, drying, brushing, and firing, are listed. Where tearing is particularly troublesome, a controlled humidity in the drier and changes in drying methods are recommended. The close control of application weight and better regulation of milling and enamel storage are necessary. Additions of nitrite or soda ash will also prevent tearing. L.E.T.

Working of enamels with low or no borax content. ALDINGER. *Glashütte*, **70** [6] 65–67 (1940).—There are batches for sheet-metal ground enamels which require not over 2 to 4% B_2O_3 calculated on the applied ground mass. If unsatisfactory results are obtained, they are probably caused by the methods of working, which offer difficulties where prescribed methods are not rigidly adhered to. Defects such as copperheads can usually be traced to incorrect pickling. Working is made easier by the use of a mixture composed of an enamel containing borax and a borax-free enamel and by gradually varying the proportion until as little borax as possible remains. The coat must be applied as thin as possible, and the firing temperature must be closely watched. The formation of copperheads can be retarded by carefully cleaning the sheet metal and dipping it in a nickel bath. See "Enamels...," *Ceram. Abs.*, **19** [5] 107 (1940). M.V.C.

PATENTS

Artificial tooth and crown of tooth. JENÖ GLÜCK. U. S. 2,194,790, March 26, 1940 (April 26, 1938).—An artificial crown for teeth or bridges comprises an outer layer of porcelain enamel.

Luminous dial. G. B. WILLIAMS. U. S. 2,194,627, March 26, 1940 (June 5, 1939).—A dial comprises a metal base, a bonding layer applied to the base and fused thereto, a layer of white vitreous enamel applied to the bonding layer and fused thereto, and a layer of luminous vitreous enamel containing radioactive material applied to the white enamel layer and fused thereto.

Glass

Accelerated methods of chemical control in the glass industry. O. V. KRASNOVSKIĬ. *Stekolnaya Prom.*, **15** [7] 29–30 (1939).—The accelerated analysis of glass is based on the determination of silica and the total quantity of the oxides of aluminum and iron from one sample, calcium oxide from another sample, and magnesium oxide and the total quantity of oxides of sodium and potassium from the third sample. Several persons may work together. (*1*) *Determination of silica and Al_2O_3 and FeO:* Silica is separated from glass by melting it with caustic soda at 480° or 500°. The melt is dissolved with strong nitric acid and is then dried. Surplus nitric acid is removed. The dry sediment is treated with ammonium nitrate and is filtered, washed, and calcined. An acid reaction is present so that the silica is free from impurities. The total quantity of the oxides of Al and Fe is determined in the silica filtrate by separating Al and Fe in the form of hydroxides with ammonia and purifying the remnants of oxides as usual. (*2*) *Calcium determination:* Glass is dissolved with hydrofluoric and oxalic acids. With repeated oxalic acid treatment of the residue, fluorine is removed and fluorides are changed into oxalates. The residue is washed and treated with acetic acid, and the oxalates are removed. The residue contains calcium oxalate, which is separated, calcined, and treated with sulfuric acid to change it into sulfate from which calcium is determined. (*3*) *Determination of MgO and Na_2O and K_2O:* Glass is dissolved with hydrofluoric acid, and the residue is removed by sulfuric acid. Calcining will change sulfates of Al and Fe into oxides. The residue is treated with water. Al and Fe are separated as hydroxides by ammonia in the presence of ammonia and acetic acid. Calcium is separated in the form of carbonates. The residue is filtered, and magnesium is separated in the form of a double salt of magnesium carbonate (method of Shaffgotta). The residue is calcined, and magnesium is determined as oxide. The dry filtrate of ammonium and magnesium carbonate is calcined, and the sulfates of K and Na are obtained. An accelerated chemical analysis of the chief glassforming raw materials has also been developed. See "Determination...," *Ceram. Abs.*, **19** [3] 77 (1940). M.V.C.

Acrylic resins in safety glasses. J. GRASSIN. *Rev. Gén. Mat. Plastiques*, **15**, 169–71 (1939); *Chem. Abs.*, **33**, 9565 (1939).—G. gives a general description and discussion based on Röhm & Haas' French patents 666,366, with additions 38,568 and 40,311, and 803,169, 812,442, and 814,353.

Antimony ruby. P. B. BUKARINOVA AND A. A. KEFELI. *Stekolnaya Prom.*, **15** [8–9] 28–31 (1939).—Soda-lime glasses are satisfactory for the production of antimony ruby. The optimum concentrates of antimony, sulfur, and carbon are (*a*) with 1.5% Sb_2O_3, 0.15 to 1.5% S and 1.25 to 0.15% C; (*b*) with 3% Sb_2O_3, 0.50 to 1.5% S and 1.5 to 0.5% C. Soda-lime glasses containing 0.5% antimony

are not suitable for obtaining antimony ruby as they are very dark and are only slightly permeable to visible light. With the introduction of small amounts of sulfur and carbon, glasses remain yellow; with larger concentrations they become dark and slightly permeable. The rubies produced are in the majority of cases dark red. Curves of spectral absorption of the visible part of the spectrum have a gentle slope which distinguishes them from curves of selenium ruby, but they have a great similarity to those of copper ruby. Antimony ruby may be used as decorative and signal red glass. Zinc glasses are unsuitable for antimony ruby because zinc combines with sulfur during melting and forms a too stable compound. M.V.C.

Burst test data on laminated glass. W. R. Koch and E. J. Wyrostek. *ASTM Bull.*, No. 103, pp. 21–25 (March, 1940).—The use of laminated glass in aviation substratosphere flying has necessitated the study of the physical properties of the glass under unusual conditions. Several different types of glasses and plastics were subjected to the testing conditions. The sizes used were the same as those generally used in airplane windshields and windows. Testing methods are described and test data are presented and discussed. A synopsis of results is given. 6 figures, 3 tables. **Discussion.** E. L. Hettinger et al. *Ibid.*, p. 25. F.F.

Condition of the cover lacquer of mirrors. Anon. *Glashütte*, **70** [3] 29 (1940).—The lacquer film to protect the silvering on mirrors must be entirely free from pores through which moisture and other destructive agents may enter. Porosity is caused by insufficient lacquer and an excess of coloring matter. It may also be caused by too rapid drying which may be partly corrected by the addition of stearate; the latter closes the pores during drying, but it cannot be used if the drying time is lengthened. In large plants where rapid drying is indispensable, the best means of preventing pores is by heating the racks where the mirrors are placed to dry, but the temperature should not approach the softening point of the resin. Another important requirement for lacquers is the absence of any free acid which might attack the silvering. Free acids must be neutralized with basic metal salts. The coloring substances in lacquer often cause injury; the sulfur in colcothar combines with silver and produces the dark brown points in the mirror. M.V.C.

Conductometric method of determining chemical stability of glasses. G. G. Samartsev and V. S. Molchanov. *Optiko-Mekh. Prom.*, **9** [8] 7–13 (1939).—The conductometric method developed by Kohlrausch (*Wied. Ann.*, **44**, 577 (1891)) was somewhat modified and used in the present experiments with good results. Distilled water and a 0.001 *N* HCl solution were used for the experiments. The general conclusion is that the quantity of acid neutralized by glass at a given moment increases with increased content of metallic oxides in the glass and with decreased silica content. It is important to note that acids destroy glass to a greater depth than water. Difficultly soluble metallic oxides, besides SiO_2, increase the protection of glass in water, but when in an acid solution these oxides are dissolved, and the protective layer is composed of colloidal silica. For a practical characterization of the chemical stability of glass it is important to determine not only the depth of destruction for a given moment but also the rate of increase of this depth. M.V.C.

Cooling of glass. Milota Fanderlik. *Sklářské Rozhledy*, **16** [7] 128–30 (1939); abstracted in *Chem. Zentr.*, **1939, II,** 4305.—Deformation during cooling produces lasting inner strains if the cooling is rapid. These deformations may be removed only in a definite temperature range, the cooling interval. The increase of the temperature by 10° within this range means doubling the cooling time for technical glasses. The cooling time increases approximately with the square of the thickness of the wall of the article. M.V.C.

Cooling process in glasses and artificial resins. Ernst Jenckel. *Z. Elektrochem.*, **43** [10] 796–806 (1937).—J. gives an elaborate study of the changes in viscosity, volume, elasticity, and index of refraction during cooling. The properties can be changed to suit demands by change of treatment during cooling. See "Glass state...," *Ceram. Abs.*, **18** [1] 17 (1939). J.M.N.

Decreasing the alkali content and increasing the chemical stability of sheet glass produced according to the Fourcault method. S. Ya. Raf and I. E. Shapiro. *Steklonaya Prom.*, **15** [10] 15–21 (1939).—The introduction of Al_2O_3 in the form of sifted refractory clay and in an amount of about 0.8% does not complicate the melting and working of glass. No additional defects related to the use of clay (streaks or stones) are observed; the qualitative indices remain unchanged. The melting of glass of the composition 71.7 SiO_2, 1.8 Al_2O_3, 0.1 Fe_2O_3, 8.5 CaO, 3.5 MgO, 0.4 SO_3, and 14.0% Na_2O and the addition of 10% Na_2O in the form of sulfate proceeds normally. This glass possesses good working properties and does not tend to crystallize more than the glass of the old composition which contained 15% Na_2O. The chemical stability of this glass is higher than that of glass containing 15 to 15.2% Na_2O. M.V.C.

Diffusion of helium through several glasses. Paul L. Smith and Nelson W. Taylor. *Jour. Amer. Ceram. Soc.*, **23** [5] 139–46 (1940).

Fiber glass, an inorganic insulation. F. W. Atkinson. *Elec. Eng.*, **58** [6] 277–82 (1939).—A. describes the manufacture and weaving of glass tape for electrical insulation and the results of tests. Fiber-glass tape is noninflammable and highly heat resistant. The operable temperature is limited only by the impregnant used, and there is a definite temperature range between the operable temperature of organic fabrics and that of heat-resistant impregnants where glass is unique. Glass tapes are also characterized by exceptionally high tensile strength; resistance to attack by moisture, acids, oils, and corrosive vapors; good thermal conductivity; excellent dielectric strength when impregnated; high insulation resistance; and nonhygroscopicity. P.G.H.

Glass fibers. P. Revest-Gindre. *Rusta-Rayonne*, **14** [7] 327–33(1939).—The manufacture of glass silk according to French patent No. 803,156 is described. Properties such as resistance to water, steam, heat, acids, and bacteria are briefly discussed. Industrial applications for electrical and thermal insulation and the manufacture of textiles and filters are reviewed. 3 illustrations. F.E.S.

Glasses colored with Nd_2O_3 and V_2O_5. V. Čtyroký. *Glastech. Ber.*, **18** [1] 1–7 (1940).—To a base glass containing 67.0 to 69.5 SiO_2, 11.6 to 12.4 CaO, 11.6 to 12.4 K_2O, and 4.0 to 4.3% Na_2O, Nd_2O_3 and V_2O_5, respectively, were added as follows to make the series of glasses studied: 6 + 0.0, 5 + 0.2, 4 + 0.4, 3 + 0.6, 2 + 0.8, 1 + 1, and 0.0% + 1.2%. Polished samples 5 x 10 x 20 mm. were studied photometrically over the range 4000 to 7000 a.u. By using the average spectral sensitivity of the eye according to Gibson and Tyndall, the transmission coefficients were recalculated to give values representing the effect on the eye of transmitted sunlight and light from a tungsten lamp. These data were plotted against the wave length for both sunlight and the electric lamp. The areas were divided at 5500 a.u. and graphically integrated. Representing the area 4000 to 5500 a.u. for sunlight by *a*, 5500 to 7000 a.u. for sunlight by *b*, and the corresponding values, respectively, for a tungsten lamp by *c* and *d*, C. found that the color belonged to the region of shorter or longer wave length depending on whether the ratios a/b and c/d were greater or less than 1, respectively. If $a/b > 1$ and $c/d < 1$, then a distinct color difference exists between sunlight and artificial light. The color changes are due entirely to the Nd_2O_3 and are proportional to the concentration. Color change is also dependent on thickness in Nd glasses. To obtain the effect for decorative purposes, a difference in wall thickness must be present so that $a/b > 1$ for the thin parts and < 1 for thick parts. See "Influence...," *Ceram. Abs.*, **18** [9] 239 (1939). J.F.H.

Heavy or light, coarse- or fine-grained soda. L. Springer. *Glashütte*, **70** [3] 29–30 (1940).—Of the four kinds of soda, viz., light, heavy, coarse-grained special glas, batch soda (these three types are high-percentage soda)

and the 90 to 92% soda with large sulfate content, which are differentiated in *Fachausschussber.* [*Deut. Glastech. Ges.*], No. 42, the coarse-grained special soda is recommended. In practice, however, the coarse-grained soda is not always suitable. S. concludes that soda for the glass batch should not be too coarse grained because it does not mix intimately enough with the other constituents, especially sand. This makes the batch harder to fuse and may produce stones in the glass. M.V.C.

Improving qualities of Fourcault debiteuse. M. S. KAZANSKIĬ AND V. I. ORZHEVSKIĬ. *Stekolnaya Prom.*, **15** [8–9] 5–13 (1939).—The necessity of improving the composition, production, and constructional details of the Fourcault debiteuse is discussed. M.V.C.

Increasing the strength of quartz glass by raising the temperature. W. DAWIHL AND W. RIX. *Z. Physik*, **112**, 654–66 (1939).—In a previous article (*Ceram. Abs.*, **18** [2] 48 (1939)) it was shown that quartz glass has about 1/3 greater strength at a temperature of 800°C. than it has at room temperature. The causes for this increase were not explained. The strength was measured by the following procedure: Many quartz glass rods about 11 cm. long and 4 mm. in diameter, narrowed down to about 3 mm. for a distance of about 1.5 cm. in the center, were made up. The testing clamps were connected, and the oven was placed over the middle of the bar. The temperature of the center was measured by a thermocouple. Tables and graphs show the variations in strength of the quartz rods at various temperatures. The range investigated was 500° to 800°C., 500°C. being the temperature at which there was the first most appreciable change in strength. The increase in strength is thought to be due to a peculiar phenomenon, which, as far as this investigation shows, can be traced to an intramolecular rearrangement. A previous theory which held that surface defects in the quartz glass were corrected at the high temperature of 800°C. and thus increased the strength of the quartz was not wholly adequate, and an intramolecular rearrangement hypothesis was therefore necessary. J.P.S.

Lengthening the life of glassmelting pots. SEMENOV. *Stekolnaya Prom.*, **15** [1] 18 (1939).—The usual life of glassmelting pots made from Druzhkovskiĭ clays is about 25 to 30 melts. To lengthen this to 40 or 50 melts without lowering the qualities of glass, special precautions should be taken while the glass is being melted. Very often the temperature of the furnace is raised unnecessarily high. This cannot exceed 1500° with new pots and 1470° or 1480° with older pots. The maximum temperature of 1500° should not last more than 30 or 40 min. During cooling, the temperatures previously determined should not be exceeded. M.V.C.

Line structures on broken glass surfaces. HELMUT WALLNER. *Z. Physik*, **114**, 368–78 (Sept. 18, 1939).—On bending and tension surfaces of glass rod fractures appear many regular line structures which result from either artificial or natural coarse niches in the glass. They originate from the combined effect of the original process cracks and elastic disturbance waves which are liberated through them in suitable niches in the glass. For this conception it is important that the speed of propagation of the cracks in the glass be less than the speed of spreading out of the disturbance waves. The authors maintain that a quantitative analysis of line structures has never succeeded until now. They attempt to explain line fractures quantitatively. Nineteen diagrams which show fractures in glass samples and graphical attempts to explain them are presented. J.P.S.

Mineral wool. Mining industry's fastest growing product. J. R. THOENEN. *Mining & Met.*, **20** [386] 101–105 (1939).—T. describes in detail the various methods of manufacturing mineral wool. Mineral wool is a generic term covering a number of similar products differentiated chiefly by the raw materials from which they are made: rock wool utilizes limestone, dolomite, shale, and clay; slag wool utilizes slags from the reduction of iron, lead, or copper ores; and glass wool utilizes the same material as is used for making soda-lime glass. Melting temperatures range from 2300° to 3400°F., steam jet temperatures range from 2000° to 2850°F., and the size of the fibers ranges from 2 to 25 microns. Comparisons are made with other types of insulation. Various types of insulation construction and the uses of mineral wool are discussed. J.J.H.

More economical lacquering with new apparatus. F. OHL. *Glashütte*, **70** [4] 42 (1940).—The new spray pistol, "Sprio-Zett-Variabel," can easily be adjusted, by pressure on the outlet lever, to give a round or flat jet without interrupting work. M.V.C.

Permissible rate of cooling glass when annealing. A. N. DAUVALTER. *Stekolnaya Prom.*, **15** [11] 28–31 (1939).—The formulas of Murgatroyd (*Ceram. Abs.*, **9** [9] 722 (1930)) used in computations of glass annealing are analyzed and criticized. See "Calculating...," *ibid.*, **18** [9] 237 (1939). M.V.C.

Processes for manufacturing glass fibers. GODOL. *Rusta-Rayonne*, **14** [12] 517–19 (1939).—G. reviews new processes for manufacturing glass fibers according to recent U. S., German, Dutch, and Belgian patents. F.E.S.

Production of cast plate glass. A. D. BARDENKO. *Stekolnaya Prom.*, **15** [8–9] 13–15 (1939).—Different defects occurring in cast plate glass are due mostly to irregular cooling between the time of casting and annealing. M.V.C.

Properties of cords and methods of recognizing them. M. A. BEZBORODOV. *Stekolnaya Prom.*, **15** [10] 25–32 (1939).—Cords are glasslike inclusions in glass and differ from it in chemical composition and physical properties, chief of which is the refraction of light. They are caused by a number of factors such as (1) changes in the glass surface because of the evaporation of some components at high temperatures, (2) the introduction of cullet of unsuitable composition, and (3) incomplete diffusion which depends upon the viscosity of silicate melts. There are surface and inner cords. Methods used for recognizing cords are briefly discussed. M.V.C.

Purifying effect of cullet containing arsenic and antimony. I. M. PROK AND L. B. POLYAKOVA. *Optiko-Mekh. Prom.*, **9** [10] 1–7 (1939).—Arsenic and antimony present in cullet completely preserve their purifying effects. These properties are observed in the temperature range which promotes the dissociation of As_2O_3 and Sb_2O_3 and the separation of oxygen. It is possible to replace the poisonous As_2O_3 by a nonpoisonous siliceous arsenic melt. A method of purifying has been suggested which is based upon the introduction of As and Sb into the batch not in the form of trioxides of arsenic and antimony but in the form of glass of a similar composition rich in As and Sb The introduction of such a concentrate changes the composition of bubbles in the glass mass, enriching them with oxygen, increasing their size, and thus promoting their elimination from the melt. Such a change of bubble composition shows the chemical effect of the fining agents used, as contrasted with the physical effect produced by the "bubbling" lumps of arsenic. The behavior of trioxides of As and Sb is not always identical in different glasses. An As concentrate purifies the borosilicate glass L-14 better than the flint glass L-8. M.V.C.

Rebuild glass tank regenerators without stopping operations. ANON. *Ceram. Ind.*, **34** [4] 84, 86 (1940).—A patent, U. S. 2,179,848 (*Ceram. Abs.*, **19** [1] 12 (1940)) is claimed to offer a solution to the problem of rebuilding regenerators without interrupting reversing operations. A drawing illustrates the design of the furnace. Vertical partitions inside regenerators provide three compartments, each of which includes a body of checkerwork and a damper in the passage into the flue. Above each checkerwork is a hollow gate connected with a blower. When one compartment is being repaired, a stream of air is delivered through the gate into the port, providing an auxiliary supply of air. When ports on the same side of the furnace as the chamber being repaired are being fired, operation is normal. When the furnace is reversed, the ports fire normally but exhausting of waste gases is modified. L.M.C.

Remodeling in glass attracts attention and dollars. ANON. *Architectural Forum*, **72** [3] 205 (1940).—Pioneering in glass-veneered façade remodeling has been a success

for Pugh Bros. in Pittsburgh. An outline of the solution of their problem is given. Illustrated. M.E.P.

Resistance of glass bottles to neutral alcoholic solutions. FRANK R. BACON AND O. G. BURCH. *Jour. Amer. Ceram. Soc.*, **23** [5] 147–51 (1940).

Secret recipe book of glass master Joh. Bapt. Eisner in Klostermühle, 1842–1862. JOSEF BLAU. *Glastech. Ber.*, **18** [1] 12–20 (1940).—The items include a large number of glass formulas. J.F.H.

Stones in glass. M. FANDERLIK. *Sklářské Rozhledy*, **16** [6] 105–12 (1939); abstracted in *Chem. Zentr.*, **1939, II**, 2958.—Difficultly fusible parts of the batch, refractories from the furnace, and devitrifications account for these defects. They are recognized by microscopical or chemical means. A table showing the type, origin, and character of these defects is given. M.V.C.

Tables for the simple calculation of glass weights for pressing. J. FLÜGGE. *Glastech. Ber.*, **18** [1] 7–12 (1940).—Numerical tables are presented along with the theoretical foundations. The tables give an accuracy of 3 to 4%. Calculations for lenses even with several facets are readily carried out. Examples illustrating the use of the tables are given. J.F.H.

Theory and practical application of the intensification of the processes of boiling and of the manufacture of glass. I. I. KITAĬGORODSKIĬ. *Trudy Moskov. Khim.-Tekh. Inst. Mendeleeva*, **1938**, No. 3–4, pp. 37–54; *Khim. Referat. Zhur.*, **1** [11–12] 114 (1938); *Chem. Abs.*, **33**, 8937 (1939).—Experiments were made on glasses containing, respectively, SiO_2 71.38, 71.34; $Al_2O_3 + Fe_2O_3$ 1.25, 1.25; CaO 9.68, 8.65; MgO 2.06, 3.11; Na_2O 14.98, 15.13; SO_3 0.75, 0.51. Both behave satisfactorily during the boiling process, and the boiling velocity is higher than that of Mg-free glass. Productivity of the entire process of glass manufacture is increased by including Mg and Al in the batch. See "Intensification...," *Ceram. Abs.*, **17** [1] 12 (1938).

Treatment of camera lenses with low reflecting films. C. H. CARTWRIGHT. *Jour. Optical Soc. Amer.*, **30**, 110–14 (1940).—An f:2 photographic lens having five separated elements was treated with evaporated fluorite to decrease the reflection from all ten air-glass surfaces. Photographs were taken with the lens under carefully controlled conditions before and after it was treated. The effective speed of the lens was almost doubled by the treatment. A slight increase in contrast resulted in photographs taken under normal lighting conditions, and a large increase in contrast resulted in those taken under adverse lighting conditions. An increase in detail was observed because of the absence of flare, and the ghost images usually observed under adverse lighting conditions were eliminated. A.P.

Variations in the absorption of a colored selenium glass as a function of temperature. J. ESCHER-DESRIVIÈRES AND Y. GODRON. *Compt. Rend.*, **210** [6] 215–17 (1940).—A piece of orange Se glass in the cold state, 2 cm. square and 5 mm. thick, was heated in a furnace, and the transmission of light was determined through two plain glass windows in the furnace walls. The transmission factors for a radiation of 6200 a.u. are 80 at 10°, 39 at 267°, and 2% at 360°C. For 5900 a.u. the factors are 63 at 10°, 47 at 51°, and 13% at 108°. The limit of the absorption spectra shows a dislocation of approximately 100 a.u. on heating the glass from 10° to 100°C. and a further dislocation of 300 a.u. on heating it up to 300°. The transparency of the glass for yellow rays is affected considerably even at room temperature, e.g., for 5750 a.u., the transmission is 12% at 10° and 8% at 24°C. These facts should be taken into consideration when using Se glasses as filters, and the temperature at which measurements on Se glasses are made should be indicated. M.H.

Viscosity of transparent fused silica. HIDEO INUZUKA. *Jour. Japan. Ceram. Assn.*, **47** [558] 292–94 (1939).—The viscosity of transparent fused silica was determined by S. English's method. The elongation Δl caused by a weight suspended from the end of the specimen was measured by a cathetometer. The viscosity was calculated from the formula $\eta = P \cdot l \cdot T / a^2 \Delta l$, where P = weight in dynes, l = length of specimen, T = time, a^2 = sectional area of specimen, and Δl = elongation. The softening temperature of the specimen was about 1150°C. When a specimen was used for each temperature, the relation between log η and temperature was rectilinear for temperatures ranging from 1130° to 1430°C. When a specimen was used for several temperatures, however, the line was a little curved for 1100° to 1200°C., probably caused by devitrification of the specimen. S.K.

PATENTS

Apparatus for:

Assembling glass applicator rods and bottle caps. C. F. SCHMIDT (Owens-Illinois Glass Co.). U. S. 2,197,714, April 16, 1940 (Nov. 2, 1936).

Casehardening glass. O. H. PADDOCK (Libbey-Owens-Ford Glass Co.). U. S. 2,194,612, March 26, 1940 (May 18, 1935).

Feeding glass to a rolling machine. PILKINGTON BROS., LTD., AND J. GASKELL. Brit. 518,415, March 13, 1940 (Aug. 24, 1938).

Grinding and polishing optical lenses. R. T. PARR AND A. T. PARR. Brit. 518,784, March 20, 1940 (Sept. 3, 1938).

Tempering glass. R. S. HINSEY (Libbey-Owens-Ford Glass Co.). U. S. 2,197,550, April 16, 1940 (Aug. 23, 1937).

Bottle-decorating apparatus. CARROLL CONE (Owens-Illinois Glass Co.). Can. 387,661, March 26, 1940 (May 26, 1937; in U. S. June 18, 1936). G.M.H.

Coloring vitreous articles and product produced thereby. O. H. PADDOCK AND A. MCK. GREAVES-WALKER (Libbey-Owens-Ford Glass Co.). U. S. 2,194,611, March 26, 1940 (Feb. 21, 1936).

Construction of hollow walls. C. M. LOCHRIE AND L. FOSTER. Brit. 518,785, March 20, 1940 (Sept. 3, 1938).

Driving mechanism for glassworking machines. T. F. PEARSON (Crown Cork & Seal Co., Inc.). U. S. 2,197,436, April 16, 1940 (Sept. 15, 1936).

Fibrous glass. PAUL EBAUGH (Owens-Corning Fiberglas Corp.). Can. 387,550, March 19, 1940 (Nov. 24, 1937; in U. S. April 10, 1937). G.M.H.

Fibrous material producing apparatus. JOHN H. THOMAS AND GEORGE M. LANNAN (Owens-Corning Fiberglas Corp.). Can. 387,660, March 26, 1940 (Sept. 18, 1937). G.M.H.

Glass-blowing apparatus. A. F. TREMBLAY (Kent-Owens Machine Co.). Can. 387,435, March 12, 1940 (Oct. 18, 1937; in U. S. Nov. 2, 1936). G.M.H.

Glass fiber drawing apparatus. CARL G. STAELIN (Owens-Corning Fiberglas Corp.). Can. 387,659, March 26, 1940 (June 12, 1937; in U. S. July 24, 1936). G.M.H.

Glass-fiber manufacture. GAMES SLAYTER AND JOHN H. THOMAS (Owens-Corning Fiberglas Corp.). Can. 387,658, March 26, 1940 (May 22, 1937; in U. S. Oct. 13, 1936). G.M.H.

Glass-fiber processing. DONALD C. SIMPSON (Owens-Corning Fiberglas Corp.). Can. 387,549, March 19, 1940 (June 17, 1937; in U. S. March 10, 1937). G.M.H.

Glass rod and tubing severing device. C. A. BROWN AND C. E. HAHN (Canadian General Electric Co., Ltd.). Can. 386,457, Jan. 23, 1940 (June 16, 1937). G.M.H.

Glass sheet bending apparatus. L. J.-B. FORBES AND G. W. T. BIRD (Pilkington Bros., Ltd.). Can. 387,281, March 5, 1940 (Nov. 28, 1938). G.M.H.

Glass sheet tempering device. L. V. BLACK (Pilkington Bros., Ltd.). Can. 387,278, March 5, 1940 (Nov. 29, 1937; in U. S. March 13, 1937). G.M.H.

Glass-spinning ring. E. F. FEEN. U. S. 2,194,930, March 26, 1940 (Nov. 26, 1938).

Glass-tempering apparatus. GEORGES MONNET (Soc. Anon. des Manufactures des Glaces & Produits Chimiques de St. Gobain, Chauny & Cirey). Can. 387,310, March 5, 1940 (June 11, 1938). G.M.H.

Glass tempering method. A. W. GROTEFELD AND J. J. SHAW (Gilt Edge Safety Glass, Ltd.). Can. 386,709, Feb. 6, 1940 (Aug. 24, 1938). J. T. LITTLETON, H. R. LILLIE, AND W. W. SHAVER (Corning Glass Works). Can. 387,-

520, March 19, 1940 (Nov. 13, 1937; in U. S. Dec. 22, 1936). G.M.H.

Glassware receiving, conveying, and uprighting apparatus. ORIE SHACKELFORD. U. S. 2,193,942, March 19, 1940 (April 5, 1937).

Glass wool. HARRY V. SMITH (Owens-Corning Fiberglas Corp.). Can. 386,501, Jan. 23, 1940 (April 12, 1937). G.M.H.

Glass wool making apparatus. J. H. THOMAS, E. FLETCHER, AND F. W. ATKINSON (Owens-Corning Fiberglas Corp.). Can. 387,548, March 19, 1940 (March 5, 1937). G.M.H.

Guide for molten material. H. K. RICHARDSON (Westinghouse Electric & Mfg. Co. and Baker and Co., Inc.). U. S. 2,190,296, Feb. 13, 1940 (Aug. 27, 1938).—A die for molten material comprises a refractory body having a tubular passage with a normally vertical axis for the flow of the material and a one-piece correspondingly shaped member formed from a sheet of platinum-rhodium alloy lining the passage, extending from the body, and having a flange formed from the sheet and normally engaging a normally horizontal surface on the body for holding the member in the passage.

Heat-absorbing glass. EDWIN BERGER (Jenaer Glaswerk Schott & Gen.). U. S. 2,194,784, March 26, 1940 (July 8, 1937).—A heat-absorbing glass contains at least 0.2% of ferrous oxide, phosphoric acid, and boric acid, the total of phosphoric acid and boric acid amounting to at least 25%, the glass further containing at least 1% of reducible oxides.

Hollow building unit. E. J. WINSHIP (Corning Glass Works). U. S. 2,194,731, March 26, 1940 (Sept. 10, 1937).

Hollow glass article. R. W. KELL (Corning Glass Works). U. S. 2,194,756, March 26, 1940 (Aug. 12, 1937; Nov. 3, 1938).

Hollow glass building block. H. L. EASTUS (Owens-Illinois Glass Co.). U. S. 2,196,109, April 2, 1940 (April 16, 1937).

Laminated glass. ERNEST W. REID (Carbide & Carbon Chemicals, Ltd.). Can. 386,844, Feb. 13, 1940 (Aug. 2, 1935). Can. 386,845, Feb. 13, 1940 (March 25, 1937). G.M.H.

Laminated safety glass. B. J. DENNISON (Pittsburgh Plate Glass Co.). U. S. 2,194,013, March 19, 1940 (April 30, 1938).

Machine and method for sealing vitreous vessels. H. D. MADDEN (Westinghouse Electric & Mfg. Co.). U. S. 2,197,527, April 16, 1940 (June 8, 1938).

Manufacture of glass ampoules. KIMBLE GLASS CO. Brit. 518,295, March 6, 1940 (Sept. 14, 1937).

Method and apparatus for forming sealed hollow articles of glass. CORNING GLASS WORKS. Brit. 518,652, March 13, 1940 (Sept. 8, 1937).

Method and apparatus for making hollow glass blocks. R. W. KELL (Corning Glass Works). U. S. 2,194,755, March 26, 1940 (Aug. 12, 1937).

Method and apparatus for making ropes or cords from glass or slag. LAMBERT VON REIS (N. V. Mij. tot Beheer en Exploitatie van Octrooien). U. S. 2,194,728, March 26, 1940 (Aug. 14, 1935).

Method and apparatus for polishing traveling flat glass. J. H. GRIFFIN (Pilkington Bros., Ltd.). U. S. 2,197,104, April 16, 1940 (Feb. 3, 1937).

Mineral wool. C. F. RAMSEYER. U. S. 2,193,982, March 19, 1940 (Nov. 2, 1936).—A mixture capable of being formed into mineral wool comprises approximately 50% oxides of silicon and aluminum, approximately 35% oxide of iron, and approximately 10% calcium and magnesium oxides.

Molded glass article. G. E. REINKER (General Electric Co.). U. S. 2,197,562, April 16, 1940 (Dec. 21, 1937).—A molded glass article consists of a compressed intermixture of two powdered glasses having different fusion points but substantially the same coefficient of expansion, the higher fusion point glass particles being substantially unfused and agglomerated by fused particles of the lower fusion point glass, the article having a dense impervious structure.

Ophthalmic lens. E. D. TILLYER (American Optical Co.). Can. 387,615, March 26, 1940 (Oct. 24, 1938). G.M.H.

Plastic material with glass fibers. GAMES SLAYTER (Owens-Corning Fiberglas Corp.). Can. 387,547, March 19, 1940 (March 5, 1937). G.M.H.

Polished glass strip producing apparatus. F. B. WALDRON AND F. E. SLOCOMBE (Pilkington Bros., Ltd.). Can. 387,279 and 387,280, March 5, 1940 (March 4, 1938). G.M.H.

Production of fibers from glass, slag, and like meltable materials. L. S. VELLO (N. V. Mij. tot Beheer en Exploitatie van Octrooien). U. S. 2,194,727, March 26, 1940 (Aug. 10, 1937).

Production of glass fibers. N. V. MIJ. TOT BEHEER EN EXPLOITATIE VAN OCTROOIEN. Brit. 519,053, March 28, 1940 (Oct. 21, 1937); addition to 515,741, Dec. 29, 1939.

Quartz seal. N. L. HARRIS AND J. W. RYDE (Canadian General Electric Co., Ltd.). Can. 387,397, March 12, 1940 (Sept. 29, 1937). G.M.H.

Sheet glass cutting apparatus. J. H. MOLLER (Libbey-Owens-Ford Glass Co.). U. S. 2,197,560, April 16, 1940 (May 26, 1938).

Silica preparation for glass batches. H. P. HOOD (Corning Glass Works). Can. 386,974, Feb. 20, 1940 (Nov. 22, 1937). G.M.H.

Tempering glass. JOHN WILSON (American Securit Co.). U. S. 2,194,730, March 26, 1940 (March 25, 1935).

Tempering glass sheets. BERNARD LONG (American Securit Co.). U. S. 2,194,760, March 26, 1940 (Feb. 11, 1935).

Structural Clay Products

Labor required to make 1000 brick, a ton of tile, and a ton of pipe. BERNARD H. TOPKIS. *Brick & Clay Record*, 92 [2] 20–21 (1938).—T. gives a summary of the man-hours required to produce and distribute clay products. Numerous tables and charts are presented. J.J.H.

Minneapolis brick pavement maintenance. H. A. WHITE. *Dependable Highways*, No. 166, pp. 3–7 (1940).—Unusual paving maintenance problems peculiar to Minneapolis weather conditions are discussed. Past and present brick pavement construction details are outlined. Brick pavement maintenance costs in Minneapolis from 1898 to 1938 are given in a table. P.S.D.

Possible causes for scumming of clay products. C. W. PARMELEE. *Brick & Clay Record*, **94** [6] 28–29 (1939).—P. briefly reviews the literature since 1928 regarding the causes of scumming of clay products. J.J.H.

Processing deaired paving brick. T. B. MCAVOY, JR. *Brick & Clay Record*, **90** [2] 92 (1937).—McA. makes many suggestions regarding the behavior of deaired paving brick throughout the processes in actual plant practice. The three main items are discussed: (*1*) *Pugging of clay:* The amount of vacuum necessary should be given more attention, and emphasis should be placed on the size, shape, and speed of the auger. The use of oil-lubricated dies improves appearance and eliminates surface crazing. The condition of the clay bar is very important. (*2*) *Firing procedure:* The water-smoking period should be held at 220° to 250° for 8 hr. and increased at a rate of 45° per hr. for the next 16 hr.; after a total of 24 hr., the temperature rise should be kept near 20° per hr. until top heat is reached. The top heat must be watched very closely to avoid glassiness. (*3*) *Prevalence of glassiness:* Glassiness

is more prevalent in high-vacuum brick; cooling of the kiln is as important as the firing procedure. It is impossible to depend entirely on a pyrometer for an accurate picture of kiln conditions. The use of plenty of trials or cones is imperative. J.J.H.

Production of hollow sand-lime brick. A. S. Razorenov and V. F. Abashkina. *Keramika*, **1939**, No. 6, pp. 40–44.—An ordinary sand-lime batch with 6 to 8% of active lime can be used. The lime must be finely ground (1 to 2% retained on a 144-mesh per cm.^{2} screen). The moisture content of the batch should be held within the limit of 4 to 5%. The batch fed to the press mixer must be moistened beforehand and mixed in a special mixer. Precautions must be taken when transporting green brick to the autoclave. P.B. & E.S.

Strength qualities of clay mortar proved in tests. E. Francis Gallagher. *Brick & Clay Record*, **92** [3] 25–26 (1938).—Tests made at the Univ. of New Hampshire Engineering Experiment Station substantiate previous studies, proving that the addition of finely ground clay to a brick mortar gives greater strength in tension, compression, and bond and lowers absorption. For best results the clay content should not exceed 8% by volume, i.e., 1.0 cement, 0.4 clay, and 3.6 parts sand. G. discusses the materials used in the tests, the method of preparing the specimens, and the final results of the tests. J.J.H.

Technical control methods available to the brick manufacturer for testing raw materials and products. Walter Marschner. *Ziegelwelt*, **70**, 83–86, 99–101, 114–15 (1939).—M. discusses the testing of the raw materials used in the manufacture of brick, e.g., the testing of clay for various undesirable impurities such as pyrites, limestone, rocks and gravel, and various organic substances. The faults which each of these impurities causes and the precautions necessary for avoiding them are conveniently tabulated. The chemical aspects of brickmaking are discussed. A complete table which classifies clays according to chemical content is presented. The finished brick and the methods available for reckoning porosity, impermeability to water, etc., are also discussed. M. attempts to discuss briefly the elementary aspects of analysis and control which should be familiar to every brickmaker. J.P.S.

SEPARATE PUBLICATION

Hydrated Lime. British Standard Specification ARP No. 24—1939. British Standards Inst., London. Price 2d.—Hydrated lime for use in cement-lime mortars used for bonding brickwork and masonry is discussed. The hydrated lime should be in the form of a fine dry powder; after ignition it must contain less than 5% magnesia and 85% lime if made from high calcium lime or 75% if made from gray lime. The proportion of carbon dioxide shall not exceed 5%. The fineness shall be such that the residue on a British Standard No. 72 sieve shall not exceed 5% and that on a No. 170 sieve shall not exceed 10%. It is determined by washing 100 gm. with a jet of water for a period not exceeding 30 min.

The soundness shall be tested by Le Châtelier's (expansion) test applied to a mixture of hydrated lime 3, Portland cement 1, and standard sand 12 parts and 12% of water. The expansion shall be tested after 1 hr. and after 24 hr. in a damp air cupboard and afterward in a steam cupboard, where the mixture is subjected to steam for 3 hr. and is then allowed to cool. The maximum permissible expansion is 10 mm. The Le Châtelier calipers are described and illustrated. A.B.S.

PATENTS

Brick-forming machine. Albert F. Stavenow. Can. 387,063, Feb. 27, 1940 (Sept. 19, 1938). G.M.H.

Building block. S. H. Markle. U. S. 2,194,047, March 19, 1940 (Oct. 13, 1938).

Ceramic building material. V. M. Goldschmidt. Can. 387,358, March 12, 1940 (Feb. 11, 1937). G.M.H.

Machine for ornamenting brick. Lionel Bentley, Batley Carr, and Edward Garforth. U. S. 2,193,916, March 19, 1940 (Sept. 14, 1938).

Method and apparatus for rough surfacing brick. G. A. Gase (H. J. Boiardi). U. S. 2,196,067, April 2, 1940 (July 2, 1936).

Refractories

Alumina and silica refractories. Hobart M. Kraner. *Iron Age*, **145** [3] 25–30; [4] 34–39 (1940).—As the metallurgist views his iron-carbon diagram in terms of changes during cooling, so the ceramic engineer views his alumina-silica diagram largely in terms of fusing tendencies in evaluating a refractory for metallurgical use. K. discusses the significance of the alumina-silica diagram, presents valuable technical information in eleven diagrams, and includes tables giving characteristics of certain clays used for firebrick, tests on brick made by different processes, effects of processing on raw materials, composition of calcined bauxites and diaspores, and thermal properties of fire-clay refractories. E.H.McC.

Basic refractories in Canada, 1914 to 1939. F. E. Lathe. *Trans. Can. Inst. Mining & Met.*, **43**, 83–99 (1940).—Production of magnesitic dolomite in Canada rose from practically nil to a large amount in the period 1914 to 1918; it rapidly declined when Austrian magnesite again became available. In 1925 the National Research Council in cooperation with producing companies and the Department of Mines began a research program which has been remarkably successful in its object of bringing about the increased application of Canadian raw materials. New products were developed, and since 1927 there has been a general sharp increase in production. The most important Canadian source of material used in basic refractories is a magnesitic-dolomite deposit at Kilmar, Que. Except for the rejection of masses of undesirable rock this is used as mined. Additional dolomite and silica, as required, are obtained from other Quebec sources. Chromite has been obtained from Canada when available as well as from world sources. Only in the period 1914 to 1918 was there a considerable production of chrome ore in Canada, and at that time the known major deposits were essentially worked out. The possibility of utilization of Ontario and Quebec brucite in refractories is being explored. Several magnesitic-dolomite thermoplastic refractories have been developed to provide materials suitable (1) for application as monolithic hearth refractories, (2) for incorporation in basic and neutral brick, and (3) as a major constituent of various cements and chemically bonded refractories. Highly satisfactory chemically bonded magnesia-base and chrome-base refractories have been developed, as well as a magnesia-chrome brick with a resistance to spalling far superior to that of magnesia brick. Both fired and chemically bonded brick are available. Chrome brick is now manufactured. Silica, fire-clay, basic, and neutral cements are made. The major applications of all products developed are given. The Canadian market is limited but a substantial export business has been built up. G.M.H.

Cast lining blocks from alumina slag for cement kilns. A. I. Zhilin and L. P. Ignat'eva. *Tsement*, **6** [6] 41–45 (1939).—Lining blocks can be cast from aluminous blast-furnace slags with a CaO content not exceeding 39%. Owing to the good crystallizing properties of the slag, the castings can be cooled to 200°C. in 3 to 4 days. The blocks obtained have good mechanical properties and are resistant to the effect of clinker, but they have low resistance to spalling. P.B. & E.S.

Ceramic properties and slag resistance of dunite products. A. S. Bazilevich. *Ogneupory*, **7** [6] 373–82 (1939).—The term dunite includes serpentines and olivinites. On the basis of microscopic study of the reaction between grains of dunite of various dimensions and magnesite, B. found that reactions occur only in the finely

ground parts of the mix, which represent a bond for the dunite grains not affected by the reaction. A study of the ceramic and refractory properties of different dunites showed that the optimum refractoriness and slag resistance is reached with 20% magnesite but that a further increase of magnesite has little effect on the properties of these refractories. The porosity of dunite refractories depends to a large extent on the presence of volatile substances in the raw material. B. suggests, therefore, that the products be fired at a high temperature (1600° or 1650°) or that raw materials with a content of volatile materials be used. The stability of pure dunite to the action of open-hearth slag is not high. With an addition of 20% magnesite, however, the resistance of dunite aggregates is higher than that of grog and silica products but somewhat lower than that of pure magnesite or chromite. M.V.C.

Chromite-alumina lining. N. I. Levin and E. G. Kanovich. *Tsement*, **6** [8] 10–14 (1939).—The use of chromite-alumina linings is effective at plants with average firing conditions. P.B. & E.S.

Chromite-alumina linings at the Bryansk cement works. N. I. Khvostenkov and A. A. Tararin. *Tsement*, **6** [7] 1–3 (1939).—Rammed chromite linings had twice the stability of chromite brick linings, owing to a greater homogeneity of the material and the absence of seams. Chromite linings on an alumina cement base gave linings for the sintering zones of rotary kilns with a higher stability than clinker concrete and talc linings. P.B. & E.S.

Condition refractories for service by laboratory testing. J. H. Chesters. *Brick & Clay Record*, **92** [3] 44–48 (1938).—C. describes the function of the works refractories laboratory and divides the work roughly as follows: (1) elimination of material unsuitable for the purpose for which it was purchased, and (2) selection and development of materials that will withstand given operating conditions. He discusses the liaison research between the manufacturer and consumer of refractories. The principal pieces of equipment used in the refractories laboratory of the United Steel Companies, Ltd., are described. Details of tests made on fire-clay, chrome, chrome-magnesite, magnesite, dolomite, and insulation refractory materials are described. J.J.H.

Development in the coke industry. C. Berthelot. *Chimie & Industrie*, **41** [2] 224–33 (1939).—Technical development in Germany, Holland, Belgium, France, and Italy is described including the combined use of silica, silicoalumina, and semisilica brick. Some of the French ovens must be modified. F.E.V.

Effect of bond clays and grog on properties of refractories. H. G. Schurecht and Jud Gustin. *Brick & Clay Record*, **93** [2] 30, 32 (1938).—The effect of varying the composition of the grog and bond clay in a typical refractory body was investigated. The following synthetic clays were prepared: a tight firing siliceous, a tight firing aluminous, an open firing siliceous, and an open firing aluminous clay. Each of these mixes was tested for volume shrinkage, porosity, absorption, bulk specific gravity, transverse strength, resistance to load at high temperatures, and resistance to slag action. The mixes having the grog and the bond clay of similar composition were superior in most of the tests. The silica content governs the ability to withstand load at high temperatures. Thermal expansion curves are included. J.J.H.

Effect of composition, charging, and conditions of firing in gas chamber kilns of Mandheim on silica brick. I. S. Shelyanskiĭ and V. D. Zigler. *Ogneupory*, **7** [6] 382–87 (1939).—Data characterizing the effect of charging, conditions of firing, and additions to the mix of crystalline quartzite on silica brick are given. Firing in a reducing or neutral atmosphere improves the qualitative indices of silica brick. M.V.C.

Effect of molten aluminum on various refractory brick. H. O. Burrows. *Jour. Amer. Ceram. Soc.*, **23** [5] 125–33 (1940).

Experiments on chrome-magnesite-dolomite mixtures: I, Effect of variation in the chromite-magnesite-dolomite ratio on firing shrinkage and resistance to hydration. A. A. Chadeyron and W. J. Rees. *Iron & Steel Inst., Special Rept.*, No. 26, pp. 175–83 (1939).—The complete ternary system of Grecian magnesite, British dolomite, and Rhodesian chromite was studied. Sixty-six compositions were fired to 1550°C. and soaked 1 hr. Firing shrinkage, accelerated hydration, and atmospheric hydration tests were performed on the specimens. Results indicate that hydration is less dependent on the proportions of dolomite present than on the amount of free lime in the fired mixture, i.e., lime which has not reacted with other constituents to form compounds resistant to hydration. It appears that these hydration-stable compounds are more easily formed by reaction with compounds such as chromite than with magnesite containing a much smaller proportion of impurities. The 80:20 dolomite-chromite, the 70:20:10 dolomite-chromite-magnesite, and several other mixtures approaching these figures were the most resistant to hydration. **II, Relationship between free lime and hydration.** *Ibid.*, pp. 185–88.—This investigation was carried out on ternary mixtures of chromite-magnesite-dolomite containing 50% and over of dolomite, since hydration in these mixtures was decidedly less appreciable than that in other mixtures of the system. Test specimens were prepared exactly as described in Part I. The specimens were crushed and ground to pass a 60 B.S.S. sieve and were stored to minimize hydration before testing. Free lime was extracted from the samples with a large excess of water and was quantitatively determined by volumetric analysis. Free lime contents varied from about 35% to less than 1%. Analysis of results indicates that the free-lime content falls rapidly up to 20% chromite content, becoming constant at approximately 1% in mixtures containing more than 20% chromite. In comparing the free-lime content with hydration results, it is shown that, in general, hydration is severe when the amount of free lime is greater than 10%. When severe hydration is not accompanied by a high free-lime content, it is attributed to the formation of magnesium compounds of a water-soluble or hydration-susceptible nature. P.S.D.

Forsterite refractories. Their origin and service in industry. R. E. Birch. *Brick & Clay Record*, **92** [6] 38–44 (1938).—B. discusses the forsterite refractory type of brick and states that it should have a composition corresponding closely to that of forsterite mineral, with the desirable variation being on the high MgO side. Forsterite rarely occurs in nature by itself but is common as olivine in homogeneous combination with fayalite ($2FeO \cdot SiO_2$). The term olivine covers a wide variety of compounds conforming to the orthosilicate formula, $2RO \cdot SiO_2$. Olivines with the RO made up chiefly of MgO and FeO are of chief interest as refractories. Forsterite refractories made in the U. S. consist largely of dunite from deposits near Asheville, N. C. Dunite occurs also on Cypress Island, Washington. The successful application of forsterite brick in the roofs of copper and lead furnaces is due to their load-carrying capacity at high temperatures and their relative immunity to the attack of FeO and other slags. Phase equilibrium diagrams of the forsterite–fayalite and the MgO–SiO_2 systems are shown. J.J.H.

Hot patching of retorts by blowpipe spray welding. T. F. E. Rhead, S. K. Hawthorn, and V. H. Deacon. *Trans. Inst. Gas Engrs.*, **88**, 329–86 (1938–39).—Following the laboratory work of Clews, Booth, and Green (*Ceram. Abs.*, **16** [7] 207 (1937)), the patching of hot retorts in service by cement fed through an oxygen-coal gas flame was adopted by the Birmingham Gas Dept. The burner consists of two concentric heat-resisting steel tubes about 15 ft. long, the center tube carrying oxygen at the rate of 60 cu. ft. per hr. with cement in suspension and the outer tube carrying gas at the rate of 100 cu. ft. per hr., burning in a blow-through burner. The oxygen near the flame is under a pressure of 15 lb. per sq. in. and the gas is under a pressure of 0.6 in. w. g. After removal of scurf from the retort, the combustion flues are put under producer-gas pressure to render all leaks visible in the retort as flames of burning gas. The burner is inserted from below, the gas and oxygen are turned on, the flame is aimed at the leak, and the cement is admitted. The hot zone is 1 in. from the burner nozzle. A hole 1 sq. in. in area can be filled in

10 to 15 min., cement being fed at the rate of $1^1/_2$ to 2 oz. per min. The total weight which the operator supports is 32 lb. Two men can repair four retorts each with three or four leaks in 8 hr. The cost of repairs is half that occasioned by the use of a gun. The most suitable cement and cement feeding devices are still matters for investigation. The present success has been attained with the 60 to 120 I.M.M. fraction of a siliceous cement with the analysis SiO_2 90.0, Al_2O_3 5.7, Fe_2O_3 0.4, TiO_2 0.3, CaO 0.5, MgO 0.15, Na_2O K_2O 0.25, loss on ignition 2.8%. The feeding device was of a "wash bottle" type, in which the oxygen stream carried the cement. Others with a screw feed and gravity feed are described. Considerable experimental work has been done on the types of blowpipes and cements. For patches on firebrick, crushed aluminous brick is good; for silica brickwork, crushed silica brick mixed with 5% of sodium phosphate, sodium aluminate, sodium carbonate, or sodium silicate or 10% of mica is successful. The patch was examined and tested by breaking it with a hammer, abrading the cut patched area on a grinding wheel, and sometimes reheating it to 1410°C. for 2 hr. The fundamental theoretical considerations of the transport of powders and the adhesion and cohesion of refractories are discussed. L.R.B.

Improving saggers. P. F. Romodan. *Keramika*, **1939**, No. 8, pp. 20–27.—The durability of saggers can be improved by adding talc or gypsum. The latter decreases shrinkage but increases water absorption. P.B. & E.S.

Magnesite linings in kilns. W. F. Rochow. *Rock Products*, **41** [4] 82–83 (1938).—R. discusses the choice of refractory materials for the lining of rotary cement kilns. He points out that the increase in operating rates and firing temperatures of the kilns has resulted in the demand for higher quality refractory material. Lining blocks with 40% alumina have given way to those with 50, 60, and 70% alumina. In some plants the 70% alumina block has been replaced by the fired magnesite and chemically bonded magnesite brick. These basic linings are giving outstanding service. Operating variables which must be taken into consideration in the choice of the refractory material to be used are enumerated. J.J.H.

Open-hearth furnace and its auxiliaries. G. D. Tranter. *Metal Progress*, **37** [1] 34–38 (1940).—T. discusses the early history of basic open-hearth steelmaking and points out the tremendous progress made in furnace design and auxiliary equipment. Many changes in designs of the open-hearth furnace were based on the limitations of the refractories or on the change in type of the refractories used. The change in the design, construction, and laying up of the brickwork has caused many changes in the checkers. Insulation and combustion control play a major part in the present furnaces. Illustrated. J.J.H.

Possible causes of destruction of refractories in electric furnaces. E. Orosco. *Rev. Chim. Ind.* [Rio de Janeiro], **8** [84] 18–20 (1939); abstracted in *Chem. Zentr.*, **1939, II**, 3736.—Although magnesite brick used for lining electric furnaces have too high a CaO and Fe_2O_3 content as compared with the standard specifications, a study of the thermal stability shows that this is not the cause of the destruction of these refractories. The acidity of the slag is not too high. O. concludes that too high a temperature (1700°) causes the destruction as it influences the initial softening of magnesite brick. M.V.C.

Processes for the manufacture of sintered magnesia products. Friedrich Reinhart. *Feuerungstechnik*, **27**, 176–79 (1939).—R. describes processes for the production of magnesia and sintered magnesia products, as well as magnesia brick and magnesia mortar, which are resistant to changes in temperature. Eighteen patents relating to some phase of the production of sintered magnesia are discussed. A suggestion is made for the production of dolomitic magnesia *usta* by leaching out the ammonia salts from the waste liquors in the Solvay process in order to free them from the calcium oxide and to sinter the leached residue. An easily fusible mixture of magnesite and zircon as binding agent in the production of magnesia brick is referred to. See "Refractories...," *Ceram. Abs.*, **19** [1] 16 (1940). J.P.S.

Recrystallization of magnesia. H. G. Schurecht and V. D. Frèchette. *Jour. Amer. Ceram. Soc.*, **23** [5] 134–36 (1940).

Refractories used in the production of steel by the basic open-hearth process: I. A. E. Dodd and A. T. Green. *Iron & Steel Inst., Special Rept.*, No. 26, pp. 21–115 (1939).—A comprehensive literature review, with a bibliography of 903 references, on steelworks refractories and refractory problems is given. The enormous amount and variety of material is divided into two major parts, viz., refractories used in the process of melting and refining the steel and refractories used in the subsequent casting operations. The furnace proper is reviewed from the viewpoints of (*a*) standard practice and (*b*) deviations from standard practice. Practice is considered standard if the furnace has a silica brick roof, walls, and port ends and if the furnace design includes a straight back wall and unrestricted and immovable ports. Standard fuel is considered to be producer gas. The conditions encountered in different parts of the standard practice furnace and their effect on the utility of the refractories are reviewed in the following order: (1) roof, (2) front wall, (3) backwall, (4) hearth, (5) blocks and ports, (6) uptakes, (7) doors, and (8) launder. The numerous opinions expressed on the requirements for the selection of refractories for standard practice are critically reviewed. Silica brick for the open hearth are considered from the following angles: influence of the raw material on the durability of the product, influence of the method of manufacture on the durability of the product, and laboratory tests and specifications for silica brick. Important work on silica cements for steel furnaces, magnesite brick, and chrome ore for the open hearth is reviewed. Deviations from standard practice are discussed. A discussion of the innovations in roof design, port end and blocks, and front and back walls is given; information on the Stevens furnace is included. The following types of open-hearth refractories are reviewed: (1) mineralized silica brick, (2) special varieties of magnesite brick, (3) chrome-magnesite refractories, (4) dolomite brick, (5) forsterite refractories, and (6) other special refractories. The influence of fuel type on the life of open-hearth refractories is described. The insulation of open-hearth furnaces is discussed as follows: (1) advantages claimed for insulation, (2) effect of insulation on silica roof brick, (3) insulating practice for open-hearth roofs and types of insulation material used, (4) necessary modifications in working control of insulated furnaces, and (5) the insulation of hearth, walls, and uptakes. A review of regenerator chambers includes (1) thermal factors depending on the properties of the refractories, (2) influence of dust deposition on regenerator fillings, (3) salvage of used checker brick, (4) effect of fuel type on checker-brick deterioration, (5) regenerator design, and (6) regenerator insulation. Three appendices to Part I include (1) discussion of the warming-up of open-hearth furnaces in which (*a*) different methods based on time-temperature records are compared, and (*b*) suitable rates of heating are reviewed; (2) measurement and control of open-hearth temperatures; and (3) the constitution of basic open-hearth slags and its influence on their viscosity. **II, Casting-pit refractories.** *Ibid.*, pp. 115–65.—Two sections, viz., (1) ladle linings and (2) ladle accessories, are included. In the first section, attack on ladle linings by the slag, attack by the molten steel, and skull formation studies are reviewed. Requirements of refractories for resisting these are considered, including such items as (*a*) composition and refractoriness, (*b*) effect of texture and method of molding, (*c*) effect of firing treatment, (*d*) after-contraction, (*e*) spalling resistance, (*f*) slag resistance, (*g*) mechanical properties, and (*h*) accuracy of shape. Ladle linings composed of material other than fire clay, joints and jointing cements, design of ladles, drying out practice, and inclusions resulting from ladle linings are discussed. The work on nozzles, stoppers, sleeves, runner brick, hot tops, and plugs is reviewed. This excellent and comprehensive review should be of great value to those engaged in the manufacture of steelworks refractories as well as to those engaged in research. It should prove very

effective in pointing out directions in which further investigation is most urgently needed. P.S.D.

Refractory cements and mortars: IV. SHOICHIRO NAGAI AND JUNZO KATAYAMA. *Jour. Japan. Ceram. Assn.*, **46**, 20–26 (1938); *Chem. Zentr.*, **1938, I**, 2936–37; *Chem. Abs.*, **33**, 8942 (1939).—Further comparative studies were made on the refractory properties of such materials and their resistance to corrosion by slags, ashes, and glass fluxes. Mixtures were prepared in ratios of 70:30 to 90:10 of a refractory ingredient of high Al_2O_3 content and a hydraulic ingredient, also of high Al_2O_3 content, and specimens were tested and compared with commercial refractory masses. Other mixtures were prepared with the addition of a third ingredient, which in the form of bentonite served as a plastic agent. In other mixtures synthetic $3CaO \cdot 5Al_2O_3$ was used as the second ingredient, and slaked lime as the third. The tests showed that these products are to be regarded as refractory cements of high quality. For Part III see *Ceram. Abs.*, **18** [3] 76 (1939).

Refractory for induction-furnace crucibles. S. M. BESEDIN. *Tsvetnye Metally*, **1938**, No. 10, pp. 86–87.—A refractory for induction-furnace crucibles comprises 67.5 crushed quartzite, 12.5 margulite, 10 fire clay, and 10% crushed glass. The components are passed through a 1 mm. mesh sieve, mixed for 10 to 15 min., moistened with 5 to 7% water, mixed again for 10 to 15 min., and passed through a 10 to 20 mm. mesh sieve. The crucible is dried for 4 to 5 hr. before use. The crucibles have a refractoriness of 1460° and a life of 330 to 350 heats. B.Z.K.

Resistant chrome-magnesite linings for the sintering zones of rotary kilns for firing cement. V. D. SIDOROV. *Ogneupory*, **7** [5] 321–29 (1939).—Attempts to use chrome-magnesite brick as a refractory lining in sintering zones of kilns firing Portland cement showed that they are far more durable than the usual linings. M.V.C.

Review of four years of research on refractory properties of Pacific Northwest olivine. HEWITT WILSON AND KENNETH G. SKINNER. *Jour. Amer. Ceram. Soc.*, **23** [5] 136–38 (1940).

Service life and economy of insulating firebrick. C. A. UNDERWOOD. *Brick & Clay Record*, **92** [5] 34–42 (1938).—U. briefly compares the methods of testing fire-clay brick and insulating firebrick. He points out that the use of insulating firebrick in place of fire-clay brick may necessitate the redesigning of the furnace or the burners used to fire the furnace. In most cases the burner capacities are excessive when fire-clay brick are replaced by insulating firebrick. U. discusses the results obtained in actual practice in the following furnaces or kilns where insulating firebrick are used: ceramic kilns, welding furnaces, the lead hardening furnace, the normalizing furnace, and the stress-relieving furnace. J.J.H.

Spalling of steelworks refractories. J. H. CHESTERS. *Brit. Steelmaker*, **6**, 71 (1940).—The spalling of refractories may be due to thermal shock, laminations and other faults in manufacture, "nipping" due to bad design and building technique, or changes in the nature of the brick during service. Spalling due to thermal shock depends on the rate of heating and cooling as well as on the conductivity, heat capacity, elasticity, and strength of the material. Regarding the two latter properties, certain types of basic refractories possess an "internal give" at low temperatures sufficient to accommodate the stresses due to thermal shock. A test in which a sawn test piece 3 x 2 x 2 in. is alternately heated at 900°C. for 10 min. and cooled in air for 10 min. gives satisfactory agreement with service results. Spalling due to faults in manufacture is particularly noticeable in casting-pit refractories. "Nipping" of refractories occurs especially in roofs, due to inadequate allowance for expansion. Chrome-magnesium refractories have a tendency to spall during use because of the absorption of iron oxide and the subsequent breaking away of the front face of the brick. R.H.

Sprung arch roofs of high-temperature furnaces: III. J. S. MCDOWELL. *Heat Treating & Forging*, **26** [2] 91 (1940).—Methods and charts for computing the strength of brickwork arches are given. Stresses due to expansion from heat are considered. For Parts I–II see *Ceram. Abs.*, **19** [3] 69 (1940). S.S.

Theories of "complete" and "incomplete" firing of grog products and their experimental testing. A. M. SOKOLOV. *Trudy Leningrad. Khim.-Tekh. Inst.*, **1938**, No. 6, pp. 256–74; abstracted in *Chem. Zentr.*, **1939, II**, 3736.—S. gives a theory which explains why refractory materials often show deformation phenomena at temperatures 300° to 400° below their refractoriness. The small amounts of easily meltable materials which are present in all clays dissolve Al_2O_3 or SiO_2 (which increases their refractoriness) until they represent solid solutions. This process requires some time before saturation takes place. Deformation phenomena may therefore be avoided when the materials are fired at sufficiently high temperature, according to their composition, and for a sufficiently long time. Experiments with clays and grog products prove the validity of this theory. M.V.C.

Thermophysical properties of magnesite brick. MASAAKI MITA. *Jour. Japan. Ceram. Assn.*, **46**, 83–91 (1938); *Chem. Zentr.*, **1938, I**, 3515; *Chem. Abs.*, **33**, 9566 (1939).—Based upon tests with eight different magnesite brick, the following requirements are given for brick used in a Siemens-Martin furnace: (1) chemical composition, MgO 87 to 88%, SiO_2 under 2%, Fe_2O_3 under 7%, CaO as low as possible; (2) density, over 2.8; porosity, under 23%; (3) resistance to compression, 1000 kgm. per sq. cm. and, after heating to 1000°, over 500 kgm. per sq. cm.; (4) thermal expansion coefficient, 1.35% at 1000°, 1.95% at 1300°, 2.1% at 1500°, no shrinkage at 1600°; (5) softening point under load (2 kgm. per sq. cm.), over 1450°; (6) specific heat, 0.2241 at 400°, 0.2448 at 600°, 0.2554 at 1000°; thermal conductivity, 0.01024 at 400°, 0.00968 at 650°, 0.00939 at 800°; (7) spalling test: heating 1 hr. at 1500° (resistance to compression, 500 kgm. per sq. cm.) and quenching in water at 18°; (8) slag test: the original value should be maintained at least 6 hr. at a steam pressure of 15 atm.

Third Symposium of Special Committee for Refractories. ANON. *Jour. Japan. Ceram. Assn.*, **47** [553] 35–41; [554] 95–105 (1939).—At the Third Symposium of the Special Committee for Refractories held by the Japanese Ceramic Assn. and the Japanese Refractories Assn., the following subjects were discussed: the method of determining P.C.E. and indicating its result, the reliability of cones, methods of testing for spalling tendency, expansion or contraction, load-bearing behavior at high temperatures, porosity, absorption, and specific gravity, chemical analysis, sampling, corrosion, abrasion, and specifications for silica, clay, agalmatolite, high alumina, and rotary-kiln refractories. S.K.

Value of refractory materials in oil boiler furnaces in the navy. A. F. ROBILLARD. *Bull. Tech. Bureau Veritas*, **21**, 127–30 (1939); abstracted in *Chem. Zentr.*, **1939, II**, 3170.—The thermal and chemical destructions occurring in the refractory linings of boiler furnaces are described, and the different refractory materials used are discussed. The tendency is to eliminate destructive chemical effects and to use linings of the greatest density. Materials rich in Al_2O_3, such as monosilicates of Al (35% SiO_2 and 61% Al_2O_3), are recommended. M.V.C.

SEPARATE PUBLICATION

Corrosion of Refractories by Soda-Ash Foundry Slag. R. S. HAFF, JR., P. S. DEAR, AND J. W. WHITTEMORE. *Bull. Virginia Polytech. Inst., Eng. Expt. Sta.*, No. 38, 26 pp. (1939).—Fourteen brands of refractories, including nine alumina-silica, a silica, two magnesite, a chrome, and a forsterite type, were tested for corrosion resistance in contact with a soda-ash foundry slag from a gray-iron foundry. Slag wells were cored in each brick with a diamond drill. Sixty-mesh drained foundry-ladle slag was packed into the slag wells. Pills of slag were placed on the surface of each brick to note the slag action on the surface skin of each brick. The brick under test, supported as simple beams, were fired to 2600°F. and soaked at this temperature for 3 hr. After the brick were cooled they were sawed through the slag well, and corrosion effects were noted. Corrosion

effects on the surface skin were noted. Petrographic studies of thin sections and powder fragments from the unused brick and from the brick after they were tested were made on each brand; these studies are discussed in relation to the use of the brick in foundry ladles in which soda ash is used as the desulfurizer. Magnesite, forsterite, and chrome brick apparently took the iron from the slag into solid solution, leaving an interstitial glass of great fluidity at the temperature of the test. These brick appeared to be unsuitable for foundry ladle linings because of the possibility of speedy erosion after the formation of the fluid interstitial material. The viscosity of the slag resulting from the contact of the alkali ladle slag with the alumina-silica series of refractories increased noticeably as the alumina content of the brand increased. A zone of more or less incipient mullite was found at the line of contact of the alkali slag and those brick of an alumina content between 30 and 60%. This zone appeared to serve as a more effective barrier for slowing up further corrosion and would perhaps also slow up erosion effects. A specially heat-treated superduty fireclay brick would very probably give increased service life over the siliceous fire-clay type now in use in the foundry because of the production of lower porosity, better volume stability, and a more homogeneous texture; these factors are very important for ladle refractories. P.S.D.

PATENTS

Checkerwork construction. E. G. Whelpley (Shea-Whelpley Construction Co.). U. S. 2,196,882, April 9, 1940 (April 4, 1939).

Furnace-door arch. L. V. Johnson (National Tube Co.). U. S. 2,197,696, April 16, 1940 (Dec. 14, 1938).

High-temperature refractory. J. D. Morgan (Power Patents Co.). Can. 387,286, March 5, 1940 (Jan. 25, 1938). J. D. Morgan and R. E. Lowe (Power Patents Co.). Can. 387,283, March 5, 1940 (Jan. 25, 1938). G.M.H.

Making refractory bodies and materials. A. R. Wood (Pilkington Bros., Ltd.). U. S. 2,195,949, April 2, 1940 (Sept. 16, 1936).—Process of making a refractory body in which the crystals are substantially only mullite by adding to a mixture consisting substantially of alumina and silica, the alumina when not hydrated being in the form of silicates, at least one of the following fluorine-containing substances in total quantity not exceeding 20%: fluorspar in quantity of 3 to 15%, lepidolite in quantity of 10 to 20%, fluorine-containing opal glass in quantity of 5 to 20%, sodium silica-fluoride in quantity of 5 to 15%, magnesium fluoride in quantity of 5 to 15%, aluminum fluoride in quantity of 5 to 15%, zinc fluoride in quantity of 5 to 15%, and firing the mixture at a temperature between 1500° and 1770°C., the alumina-silica ratio in the whole mixture being between 1.2 and 2.75.

Making refractory bodies and materials. A. R. Wood (Pilkington Bros., Ltd.). U. S. 2,195,950, April 2, 1940 (Sept. 16, 1936).—Process of making a refractory body consisting of crystals in a glassy matrix in which the crystals are substantially only corundum by adding to a mixture consisting substantially of alumina and silica, the alumina when not hydrated being in the form of silicates, a not readily soluble fluorine-containing substance and firing a body formed of the mixture at a temperature between 1350° and 1770°C., the mixture being partially in plastic form and having an alumina-silica ratio above 3.5.

Manufacture of artificial magnesite, etc. Charles Hart. U. S. 2,195,367, March 26, 1940 (March 30, 1936). The method of preparing an artificial magnesite refractory comprises calcining a dolomite or like magnesium-calcium compound containing an iron compound as a native impurity, treating the calcinate with a strong cycling sucrose solution having a sucrose concentration of 20 to 30% and centrifugally separating the sucrate liquor, washing the undissolved residue with a weak sucrose solution in a cyclic manner to effect a strengthening of the weak sucrose solution by abstracting calcium sucrate from the undissolved residue, the proportions of sucrose solutions employed being effective to reduce the calcium content of the insoluble matter to less than 8% as calcium oxide, from time to time adding the cycling strengthened weak sucrose solution and sucrose to the cycling strong sucrose solution to maintain the volume and concentration thereof, carbonating the cycling sucrose solution to convert calcium sucrate to calcium carbonate and sucrose, terminating such carbonation while the solution is still alkaline and separating the calcium carbonate from the sucrose solution, returning the sucrose solution in cycle as aforesaid, carbonating the aforesaid undissolved residue in the presence of water and thereby effecting a solution of a part of the magnesium as acid magnesium carbonate and removing the dissolved magnesium compound whereby to increase the relative proportion of iron with respect to the magnesium present, and recalcining the insoluble matter including the remaining magnesium and iron compounds to produce the artificial magnesite refractory.

Porous refractory. J. D. Morgan (Power Patents Co.). Can. 387,287, March 5, 1940 (Jan. 25, 1938). G.M.H.

Refractory blocks for the construction of furnaces. V. M. Goldschmidt. Brit. 518,440, March 13, 1940 (Aug. 30, 1937).

Refractory bonding method. J. D. Morgan (Power Patents Co.). Can. 387,285, March 5, 1940 (Jan. 25, 1938). G.M.H.

Refractory and method of making. I. M. Logan and J. C. McMullen (Carborundum Co.). U. S. 2,196,075, April 2, 1940 (July 9, 1936).—In the process of producing substantially nonporous castings from a melt comprising at least 75% alumina and less than 5% of alkali oxide, the melt, upon solidifying, providing a porous structure, the steps comprise incorporating in the melt alternately small portions of carbon and a substance selected from the group consisting of bauxite, rutile, and ferric oxide, so proportioning the portions that a sample of the fusion taken in a test ladle and quenched will show substantially no pores, the total amount of carbon in the melt being no more than sufficient to substantially eliminate the pores, and casting the melt in the condition corresponding to the nonporous sample.

Runner spout for tilting crucibles. Furman South, Jr. (Lava Crucible Co.). U. S. 2,195,523, April 2, 1940 (Nov. 29, 1937).

Zirconia zircon silicon refractory. J. D. Morgan (Power Patents Co.). Can. 387,284, March 5, 1940 (Jan. 25, 1938). G.M.H.

Whiteware

PATENTS

Aviation spark plug (radio shielded). Julius Devine. U. S. 2,194,695, March 26, 1940 (Nov. 5, 1938).

Chemical apparatus. C. A. Weller. U. S. 2,195,436, April 2, 1940 (Dec. 30, 1937).—Chemical laboratory ware for high temperature ignition purposes is comprised of refractory ceramic materials having the surface covered with an adherent noble metal coating.

Making articles of porcelain. R. W. Erdle (Dental Research Corp.). U. S. 2,195,452, April 2, 1940 (Nov. 4, 1935).—In a process for making a mold for porcelain articles the steps comprise making a pattern, coating the pattern with a material which will not combine with fused porcelain and which will give the mold cavity a smooth hard finish, investing the pattern in a body of investment material, setting the body of investment material, transferring the coating material from the pattern to the investment material, and eliminating the pattern to form a smoothly coated mold cavity.

Pole-line insulator. H. H. Wheeler, Orris McGinnis, and William Thordarson (Western Union Telegraph Co.). U. S. 2,194,189, March 19, 1940 (May 5, 1936).—

A method of making an insulator having a surface layer of high electrical resistivity, high permanency, and high interfacial tension with water comprises heating the body of the insulator to a high temperature and forming the surface layer by applying to the surface of the body when thus heated a hydrosol formed from a soluble salt of a group consisting of acetates, nitrates, chlorides, and sulfates of a metal.

Spark plug. JOE CECCON. U. S. 2,195,953, April 2, 1940 (Aug. 30, 1939). C. M. SONGER. U. S. 2,195,543, April 2, 1940 (June 26, 1939). K. L. G. SPARKING PLUGS, LTD., C. M. CARINGTON, AND G. W. SHOOBERT. Brit. 519,045, March 28, 1940 (Sept. 13, 1938). L. G. WALTER AND H. R. WEBBER. U. S. 2,194,251, March 19, 1940 (Dec. 16, 1939).

Equipment and Apparatus

Apparatus for luminescence analysis and its use for the investigation of silicates. B. S. SHVETSOV, M. A. MATVEEV, AND YU. P. SIMANOV. *Keramika*, **1939**, No. 8, pp. 5–12.—The apparatus is an electric, a-c., mercury vapor, quartz (nonvacuum), 380- to 400-watt lamp equipped with a filter transmitting ultraviolet rays and with a device for microscopic observation. Stable slags give a homogeneous dark-violet or dark-brown (more rarely, bright-violet) luminescence. Older slags sometimes show isolated gold-yellow or silver-white patches or efflorescence due to weathering. Unstable slags show a light break in the surface, multiple iridescent white-yellow and bright-yellow points on a bright-violet ground, and sometimes rust-brown patches with light-brown points. The method can be used for determining the extent of mullitization of fused mullite ware, refractories, porcelain, etc. P.B. & E.S.

Arrangement for precision measurements of thermal expansion (a highly sensitive, quick-acting thermostat). K. H. FISCHER. *Z. Instrumentenk.*, **59** [9] 341–57; [10] 385–96 (1939).—Methods of determining thermal expansion, their principles, and the demands made on them for precision are discussed at length. F. describes a new arrangement for precision measurements in the range from −20° to +200°C. The bath for heating the specimen consists of Cymol ($C_{10}H_{14}$) which has a low viscosity over the whole range, solidifies at −73°C., boils at +175°, does not attack metals, is not harmful to health, and is not inflammable. Measurements are given and the exact procedure and equipment are described in detail. Twenty-eight references. M.H.

Determination of working properties of casting slurry. E. A. ULATOV. *Keramika*, **1939**, No. 7, pp. 41–43.—An areometer is introduced for 3 min. into a cylinder containing the slurry whose specific gravity has been previously determined pycnometrically. The difference between the determinations characterizes the inner friction of the slurry ($Q = \gamma - \gamma_1$). P.B. & E.S.

Dilatometer for determining bound water in soils and other colloidally dispersed materials. T. F. BUEHRER AND M. S. ROSENBLUM. *Jour. Phys. Chem.*, **43**, 941 (1939).—Details of the construction and use of a dilatometer designed to give precise control of experimental conditions are given. The effects of changes in the temperature of the freezing bath and the capillary were investigated, and a correction to be applied to the observed data is deduced. Results reproducible to within 1 or 2% are claimed. R.A.G.

Effect of the condensation of steam on the drying of ceramic ware. A. A. SHUMILIN. *Ogneupory*, **7** [4] 246–51 (1939).—The condensation of steam or vapors during drying lengthens the drying period. To lower condensation S. recommends (1) decreasing the initial moisture of raw materials and (2) increasing the initial temperature of raw materials by using hot water during the working of the mix. M.V.C.

Errors in optical pyrometry. D. VERMEULEN AND J. J. ZAALBERG VAN ZELST. *Het Gas*, **57** [16] 257–60 (1937).—Errors which may occur in measuring temperatures with the total-radiation pyrometer and with the monochromatic pyrometer are described, and these two pyrometer systems are compared. There is a much greater possibility of error with the total-radiation pyrometer than with the monochromatic pyrometer. Although the measurement of temperatures with the total-radiation pyrometer is more simple, it seems to be unsuitable for use in factories. W.L.

Nature of the ore-forming fluid. L. C. GRATON. *Econ. Geol.*, **35** [2, Supp.] 197–358 (1940).—Starting from the arguments and conclusions of Fenner, Bowen, Ross, and Schaller in the "Lindgren Volume" ("Mineral...," *Ceram. Abs.*, **13** [10] 273 (1934)), G. appraises present knowledge and theory of the origin, state, composition, migration, and effects of the mobile medium which transports mineral-forming materials from the magma and deposits them to form the hypogene epigenetic ores. The conclusions deal with timing, mechanism of separation, motive power, recondensation, alkalinization, alkalic vs. acidic alteration, descent of alkalinization, alkaline reworking, volatile halogen compounds, test of acidity, causes of mineral deposition, liquid vs. gas, and an explanation of gas and acid; a summation is included. J.L.G.

Psychrometric chart, application and theory: IX. WILLIAM GOODMAN. *Heating, Piping & Air Conditioning*, **12** [2] 107–10 (1940).—G. considers the temperature of adiabatic saturation and percentage humidity. One chart, two numerical examples. For Part VIII see *Ceram. Abs.*, **19** [5] 121 (1940). J.L.G.

Radiation correction in calorimetry. F. E. HOARE. *Phil. Mag.*, **29** [192] 52–65 (1940).—Different methods of making the radiation correction in calorimetric experiments are reviewed, and the limits of permissible error are discussed. R.H.

Stability of base-metal thermocouples in air from 800° to 2200°F. ANDREW I. DAHL. *Jour. Research Nat. Bur. Standards*, **24** [2] 205–24 (1940); RP 1278. Price 10¢.—The thermal e.m.f. of each element against platinum was measured to determine the relative stability of the individual elements. A few tests were made to determine the effect of wire size on the stability. The effects of changing the depth of immersion of thermocouples after they had been used under controlled conditions were also studied. Since all tests were made in an atmosphere of clean air, the results give no information on stability except under oxidizing conditions. Long-time exposure of a Chromel-Alumel thermocouple to high temperatures causes the e.m.f. corresponding to a given temperature to increase or the temperature corresponding to a given e.m.f. to decrease. The effect on an iron-constantan thermocouple is the reverse. The results of the immersion tests emphasize the importance of never decreasing the depth of immersion of a couple after it has once been placed in service. R.A.H.

Thermal analysis. V. A. KIND, S. D. OKOROKOV, AND E. P. KHODIKEL. *Tsement*, **6** [7] 32–37 (1939).—Dehydration curves were obtained with the aid of a device suggested by N. S. Kurnakov which photographically registers galvanometer readings. The differential method was used for determining temperature intervals. Observations were made with hydrated tricalcium silicate, β-dicalcium silicate, tricalcium aluminate, dicalcium ferrite, brownmillerite, and calcium hydrosilicate and hydroaluminate obtained synthetically in an aqueous medium, and dehydration curves are shown graphically. The method is a good means for the investigation of dehydration processes. P.B. & E.S.

Use of radiography in the development of castings for mass production. DON M. MCCUTCHEON. *ASTM Bull.*, No. 103, pp. 13–16 (March, 1940).—M. discusses the procedures and technique employed by the Ford Motor Co. in testing castings for mass production. With the radiographic method a sensitivity of 0.5% is maintained on a $2^1/_4$-in. bearing. Standard radiographic clay (clay with powdered lead) is used as a blocking medium; lead salt

solutions are also used. Microphotometer tests are made on the radiographs. Magnaflux magnetic tests are used for the detection of cracks in forged, welded, and cast automobile parts. Six figures. F.F.

SEPARATE PUBLICATION

Eykometer, a new device for measuring the yield point of clay suspensions and oil well drilling muds. A. GEORGE STERN. *U. S. Bur. Mines Repts. Investigations*, No. 3495, 21 pp. Free.—Results of tests on fourteen muds show that solidifying strength or yield value can be measured reproducibly in an eykometer. R.A.H.

PATENTS

Apparatus for sandblasting ceramic ware. J. A. BOWER (Taylor, Smith & Taylor Co.). U. S. 2,195,810, April 2, 1940 (Nov. 11, 1937).

Clay pin making apparatus. W. B. LOUTHAN (Louthan Mfg. Co.). U. S. 2,197,699, April 16, 1940 (June 9, 1938).

Color chart. S. B. MCDONALD. U. S. 2,196,397, April 9, 1940 (Oct. 20, 1937).—The combination, with a base having a plurality of color panels thereon arranged radially about a common central point in spectrum sequence with complementary colors diametrically opposed and with colors forming a triad separated by arcs of 120°, of a pair of dividers embodying a pair of arms, means for pivotally supporting the divider arms at the central point for bodily swinging movement toward and away from one another and about the central point, indicating means movable into registry with successive ones of the color panels, and means operatively connecting the arms with the indicating means for maintaining the latter in registry with the center line between the divider arms irrespective of the position of bodily adjustment of the arms about the central point or with respect to each other.

Device for finely cutting clay, etc., into small disks and shells. K. REISSMANN AND E. REISSMANN. Brit. 518,436, March 13, 1940 (Jan. 5, 1938).

Machine for printing on jars. D. W. KNAGGS (Anigraphic Process, Inc.). U. S. 2,195,625, April 2, 1940 (July 28, 1937).

Means for comparative determination of transmitted and reflected light. L. G. TOWNSEND. U. S. 2,196,234, April 9, 1940 (May 27, 1938).

Molding ceramic articles. R. W. ERDLE (Dental Research Corp.). U. S. 2,196,258, April 9, 1940 (Sept. 21, 1936).

Separation of particles from gases. ARTHUR NUTTING (American Air Filter Co., Inc.). U. S. 2,195,707, April 2, 1940 (Jan. 5, 1938).

Kilns, Furnaces, Fuels, and Combustion

Automatic control of furnace atmospheres. H. M. WEBBER. *Instruments*, **13** [3] 73–76 (1940).—Present heat-treatment methods are, to a great extent, performed in furnaces provided with controlled atmospheres. The furnace atmospheres employed are completely independent of the heat source and are supplied and controlled by the use of auxiliaries. W. discusses the various auxiliaries under the following headings: (1) preparing the gas, (2) moisture removal, (3) refrigerated gas cooler, (4) activated alumina drier, (5) dew-point potentiometer, (6) sulfur removal, (7) carbon-dioxide removal, and (8) volume and pressure control. Illustrated. J.J.H.

Carbonization at low temperature and detailed analysis of products. A. GILLET AND P. CHERSTNIOFF. *Chimie & Industrie*, **42** [6] 944–53 (1939).—An apparatus is described which allows carbonization at 400° to 600°C. and precise analysis of distillation products. Results of tests are tabulated. F.E.V.

Cleaning coal by heavy liquids. M. G. DRIESEN. *Mech. World*, **105** [2732] 468–69 (1939).—The coal-cleaning process used in Dutch government mines is described. The loss of coal in a primary jigwasher amounts to 2 to 3% of the raw coal, but in a modern heavy-liquid washer using a suspension of loess it is only 0.5 to 1.0%. Five illustrations. F.E.S.

Delayed combustion in downdraft kilns. J. GEORGE SEANOR. *Brick & Clay Record*, **92** [6] 26–28 (1938).—S. explains the pumping action of the fireboxes and points out that this action is an aid to combustion. There is little difference in the workings of various fireboxes, and the lazy flame furnace principle is adaptable to clay-plant burning. Illustrated. J.J.H.

Draft and fast firing. L. R. WHITAKER. *Brick & Clay Record*, **92** [2] 23, 27 (1938).—W. discusses kiln firing and states that the draft is of prime importance in firing. He suggests methods for controlling it and a procedure to follow in firing a kiln. Firing-control methods are briefly discussed. J.J.H.

Periodic gas kiln for firing refractories. V. P. USPENSKIĬ. *Trudy Ivanov. Khim.-Tekh. Inst.*, **1939**, No. 2, pp. 82–88; *Chem. Abs.*, **33**, 8943 (1939).—A periodic gas kiln for firing refractories is described with the aid of diagrams. The kiln is equipped with four burners and a recuperator for preheating the air for the burners. If necessary, the kiln can be operated with producer gas without the use of preheated air from the recuperator. A temperature of 1450° may be obtained with a relatively small amount of fuel.

Stability of a kiln stack. T. W. GARVE. *Jour. Amer. Ceram. Soc.*, **23** [5] 152–56 (1940).

Geology

Behavior of colloidal suspensions with electrolytes. E. A. HAUSER AND S. HIRSHON. *Jour. Phys. Chem.*, **43**, 1015 (1939).—When iron oxide sol is added to bentonite sol, the final equilibrium viscosity of the system goes through a first maximum for small additions, a minimum, and a second maximum at about 50% iron oxide in the system. The first maximum is considered to be due to the orientation of the bentonite particles about the iron oxide particles. The second maximum occurs when the iron oxide particles condense around the bentonite particles and syneresis takes place. Developments of this theory offer a new means of predicting the behavior and gelation of electrostatic sols. R.A.G.

Chemical resources of the Southwest. W. A. FELSING. *Jour. Chem. Education*, **16** [5] 212–14 (1939).—F. describes the possibilities for industry in Arkansas, Louisiana, New Mexico, Oklahoma, and Texas. He mentions the existence of gypsum, cement rock, clays, bentonite, fuller's earth, and pure sands for glass manufacture. P.G.H.

Chemical study of chromite from the Orsova mountains (Banat). ELISA LEONIDA-ZAMFIRESCU. *Inst. Geol. Romaniei*, No. 12, pp. 1–31 (1939); abstracted in *Chem. Zentr.*, **1939, II**, 2628.—The Cr_2O_3 content varies between 13.8 and 41.7%. The analysis was possible only after repeated melting with Na_2O. The methods used for analysis of the separate components are discussed in detail. Free Al_2O_3 is obtained only after long oxidation with Cl_2; its content fluctuates between 15.6 and 26.7%. Only traces of Mn were found. The high content of MgO (12.2 to 24%) is due to the presence of serpentine; spinel and chlorite are also present. M.V.C.

Colloidal behavior of clays as related to their crystal structure. T. F. FORD, A. G. LOOMIS, AND J. F. FIDIAM. *Jour. Phys. Chem.*, **44**, 1–12 (1940).—The coagulating effect of most salts on clay suspensions is attributed to changes in concentration of the interparticle ionic atmospheres. Salts such as sodium tannate, sodium silicate, and phosphates, which reduce the apparent viscosity of concen-

trated clay suspensions, appear to be adsorbed on the clay particles and to destroy the aggregation of the particles. Chemical formulas based on detailed crystal structure are written for colloidal clay particles and are used in explaining various phenomena encountered with clay suspensions. R.A.G.

Concentration of sand used in glassmelting. A. M. Tsekhomskiĭ and S. E. Fridman. *Stekolnaya Prom.*, **15** [8–9] 16–18 (1939).—An analysis of the chemical composition of the chief Russian sand deposits is given. Methods of concentrating, such as magnetic separation and washing, are mentioned. M.V.C.

Cristobalite from the Sárospatak region. Endre Lengyel. *Földtani Közlöny*, **67**, 309–14 (1937); abstracted in *Chem. Zentr.*, **1939, II**, 2517.—Cristobalite and tridymite are found in small quantities in red-brown oligoclase, andesine, biotite, quartz, glass, and sphaerocrystals containing rhyolite. M.V.C.

Developing Canada's nepheline syenite. C. M. Nicholson. *Can. Mining Jour.*, **61** [3] 135–46 (1940). G.M.H.

Diffusion in solid bodies and corrosion between crystals. Use of geological observations in the chemistry of silicates. Marcel Roubault and René Perrin. *Compt. Rend. 18me Congr. Chim. Ind.*, **1938**, 1088–95; abstracted in *Chem. Zentr.*, **1939, II**, 2759.—The possibility of reaction in the solid state in rock and mineral formations is dealt with on the basis of cross sections and known petrographic and geological observations. M.V.C.

Exchange of univalent and multivalent ions in soil and glauconite. V. I. Paramonova and P. M. Chulkov. *Kolloid. Zhur.*, **5**, 185–91 (1939); abstracted in *Chem. Zentr.*, **1939, II**, 2515.—The ionic exchange of K and NH_4 in black soil and of $Ca^{\cdot\cdot}$ and $Na^{\cdot}$ in glauconite under stabilized conditions with respect to coefficients of activity was studied. Under these conditions the results agree with theory. M.V.C.

Firing ceramic products by method of continuous registration of physicochemical changes in the body. A. K. Freberg. *Ogneupory*, **7** [4] 216–22 (1939).—An attempt was made to correlate the process of mullitization of kaolin clays of the Latnanskiĭ deposits with the physicochemical changes appearing in these clays on firing, particularly with shrinkage and thermal effects during thermal analysis. The method of continuous registration in the 950° to 1425° range was used. The temperature range in which the processes of shrinkage and mullitization correlate well was determined, especially (*a*) the range between 1150° and 1250°, which corresponds to a sudden increase in the mullite content (which is insoluble in a 20% hydrofluoric acid solution) and a severe increase of shrinkage, explained by the sintering phenomenon; and (*b*) the range between 1250° and 1500°, characterized by a slower process of mullitization and shrinkage. The method of mullite determination by means of a treatment of clay samples fired to 1100° to 1200° with a 20% hydrofluoric acid solution cannot be used, as the products of kaolinite decomposition are completely dissolved in the acid. M.V.C.

Gelation and film formation: II. E. A. Hauser and D. S. Le Beau. *Jour. Phys. Chem.*, **43**, 1037 (1939).—Coherent self-supporting films produced from colloidal hydrous aluminum silicates were used. An apparent discrepancy in the influence of particle size on water retention by the film is explained in terms of the modern theory of the structure of montmorillonite. The influence of higher temperatures and of electrolytes on the films is discussed, and microphotographs are given. For Part I see *Ceram. Abs.*, **19** [1] 26 (1940). R.A.G.

Influence of the change of the chemical composition of different oxides on the properties of fused minerals. A. S. Ginzberg and Ya. Ya. Lisyutin. *Trudy Petrograf. Inst.*, **1938**, No. 12, pp. 213–24; *Khim. Referat. Zhur.*, **1** [11–12] 112 (1938); *Chem. Abs.*, **33**, 9567 (1939).—The influence of different oxides on the fundamental casting and crystallization properties of fused minerals was investigated. The experimental fusions were performed under laboratory as well as under semiplant conditions. Siberian traps were used as starting materials. The change of SiO_2 composition was investigated in the first series of mixtures, of Al_2O_3 composition in the second series, and of Fe composition in the third series. Substances which approach in their composition the normal traps and basalts possessed the best petrological properties. An increase of the acidity caused an increase of the η and also affected adversely the crystallization properties. A basic increase of the mixture changed the casting and the crystallizing properties favorably, but, owing to the formation of cracks, it decreased the acid-resistance properties as well as the mechanical and electrical indices. A slight change in the Al_2O_3 content influenced the formation in the traps of a porcelainlike structure, which increased the acid-resistance properties.

Kaolinized Tirschenreuth granite, which has been referred to in ceramic work as "pegmatite." J. H. Hellmers and P. Pfeffer. *Z. Prakt. Geol.*, **47**, 192–96 (1939); *Chem. Abs.*, **34**, 966 (1940).—Microscopic study and analyses of samples from four depths show that the kaolinization is a surface phenomenon and decreases rapidly with depth.

Lamellar structure of potash-soda feldspars. S. H. Chao and W. H. Taylor. *Proc. Roy. Soc.* [London], **A174**, 57–72 (1940).—New and more detailed X-ray examination of orthoclase-microperthites confirms the theory that the occurrence of different types of lamellar structure depends upon whether the proportion of soda feldspar is greater or less than 30% (see "X-ray. . .," *Ceram. Abs.*, **14** [4] 100 (1935)). The constitution of the soda feldspar and the bearing of the new data on the general theory of microperthitic structures are discussed. See "X-ray. . .," *ibid.*, **18** [10] 280 (1939). A.P.

Manganese, a "most strategic" mineral. F. G. Kuehl. *Foote-Prints*, **12** [2] 1–10 (1939).—Manganese deposits are widespread, but Russia and India ordinarily produce 70% of the world's production. During the war, the U. S. may have to turn to Brazil and Cuba for its needs. Extensive prospecting has failed to uncover any large commercial deposits in the U. S. A.P.

Mineralogy of the Tikhvin bauxites. E. P. Levando and N. A. Adamova. *Zapiski Vserossiĭskogo Mineral. Obshchestva*, **67** [1] 74–80 (1938); *Khim. Referat. Zhur.*, **2** [4] 37 (1939); *Chem. Abs.*, **34**, 963 (1940).—By mechanical and chemical treatment of the bauxite samples of the Tikhvin region, fine, opaque, white, isotropic grains with $n = 1.647 \pm 0.002$ were obtained. The separated substance is $Al_2O_3 \cdot H_2O$ with small admixtures of SiO_2, Ti, and Fe and with a somewhat larger amount of water than that called for by the formula. On the basis of the chemical and optical studies, as well as from a comparison with the French bauxites, the mineral can be regarded as a noncrystalline hydrated Al_2O_3 of the boehmite type which is formed as a result of aging of the gel-like substance.

Nature and origin of flint. K. P. Oakley. *Science Progress*, **34**, 277–86 (Oct., 1939).—O. discusses the ideas about flint which have been expressed by geochemists and others. The Old English term "flint," which originally meant any hard, rocklike mineral, has come to denote a form of nodular silica, with granular structure and perfect conchoidal fracture, occurring in limestone. This discussion is limited to nodular silica in European chalk. O. describes flint and discusses the proposed theory for its origination syngenetically through the direct precipitation of inorganic silica from sea water in the form of a colloidal gel. He lists the considerations against the application of this theory and feels that they also apply to the theory of penecontemporaneous origin. The time of the main generation of flint in the chalk was probably shortly after consolidation, when the formation was being uplifted at the end of Cretaceous times. In spite of certain unsolved problems, O. considers that Wroost's theory of the mechanism of epigenetic replacement goes much further in providing a complete explanation of Cretaceous flint than any previous one. He hopes that this brief exposition will focus attention on Wroost's work and stimulate geologists and physical chemists to give it critical consideration. F.S.M.

Pyrite and marcasite as troublesome substances in the manufacture of ceramic ware. JOSEF MATĚJKA. *Stavivo*, **18**, 381–82 (1937); *Chem. Zentr.*, **1938, I**, 2040; *Chem. Abs.*, **33**, 8939 (1939).—The possibilities of avoiding undesirable effects are discussed.

Refractory slate from Egorshino. F. F. BAĬ-BALAYEN. *Razvedka Nedr*, **9** [4–5] 22–25 (1939); abstracted in *Chem. Zentr.*, **1939, II**, 2577.—The slate is characterized by a high Al_2O_3 content of up to 47%. M.V.C.

Sary-Adyrskoe deposits of refractory clays of the flint-clay type. E. I. ORESHNIKOVA. *Razvedka Nedr*, **9** [4–5] 19–22 (1939); abstracted in *Chem. Zentr.*, **1939, II**, 2699.—These clays are similar to American clays of the same type in regard to chemical composition and ceramic properties. M.V.C.

Theoretical mineralogy of soil colloids (pedology). I. D. SEDLETSKIĬ. *Zapiski Vserossiĭskogo Mineral. Obshchestva*, **67**, 627–50 (1938); abstracted in *Chem. Zentr.*, **1939, II**, 3033.—The two main classes of minerals found in soil are (1) minerals of soil-building mother rock (eruptive rocks, metamorphous rocks, argillites), and (2) colloidal minerals (pedosilicates, humites, humus silicates, and oxides of Al, Fe, and Si). The latter have been studied only slightly; they are present in a state of continuous further development. Kaolinite, halloysite, and pyrophyllite are formed under acid conditions, and montmorillonite is formed under alkaline conditions. Sometimes montmorillonite is present under acid conditions and kaolinite under alkaline; this is accounted for by the fact that the separate particles are surrounded by an amorphous lining which protects them from further attack. The structure of the separate soil particles is varied. There is a variety of cores and covers in the individual micelles which yield a picture of the origin of the soil. In the course of time, these amorphous cases may take up a corresponding crystal lattice. M.V.C.

U.S.S.R. flint clays. A. D. FEDOSEEV. *Ogneupory*, **7** [4] 273–80 (1939).—A general review of flint clay deposits and similar raw materials found in Russia is given. M.V.C.

SEPARATE PUBLICATIONS

Ceramic Silica Possibilities in Virginia. JOHN W. WHITTEMORE AND PAUL S. DEAR. *Bull. Virginia Polytech. Inst., Eng. Expt. Sta.*, No. 43, 23 pp. (1940).—The varied requirements and specifications relating to silica sand for the ceramic industries are discussed in detail. Previous literature on ceramic silica in Va. is reviewed, and present ceramic silica plants in Va. are described. Microscopic examinations and mechanical and chemical analyses of a number of sand, sandstone, and quartzite samples from different parts of the state are reported and discussed with reference to ceramic silica possibilities. The studies indicate that deposits of silica of suitable purity for ceramic raw material usage occur in different parts of the state. Many are favorably located for quarrying and are near to lines of transportation and abundant fuel supplies. A map of Va., showing the location of the reported samples, is included. P.S.D.

Electrometallurgical Investigations: Metallurgical Division Progress Report No. 35. J. KOSTER, R. G. KNICKERBOCKER, O. C. GARST, T. E. EVANS, AND W. E. CODY. *U. S. Bur. Mines Repts. Investigations*, No. 3483, 27 pp. Free.—The recovery of nickel, copper, and precious metals from domestic ores by a combined electrothermal and electrolytic method is discussed. R.A.H.

Ore-Dressing Studies: Metallurgical Division Progress Report No. 36. A. L. ENGEL AND S. M. SHELTON. *U. S. Bur. Mines Repts. Investigations*, No. 3484, 33 pp. Free.—The authors describe ore-testing projects on nine manganese ores, either low grade or complex; lead carbonate ore from Nevada; antimony ore, talc ores, and chromite ore from California; feldspar from Minnesota; crude white lead and sphalerite ore from Missouri; fluorspar mill tailings from Illinois; silica sand from Ohio; and copper ores from Colorado. R.A.H.

Sedimentation and flocculation. M. B. DONALD. *Trans. Inst. Chem. Engrs.* [Preprint], Dec. 6, 1939.—In sedimentation there is a critical point when the rate of settling drops suddenly from a comparatively fast rate to a slow rate. The rate of sedimentation is constant up to the critical point with clays peptized with alkali, but it is accelerated with time if the clays are flocculated with acid. The acceleration may be caused by the formation of larger flocs or by the flocs forming a loose structure below, which is broken down as more solid is piled on it from above. Flocculated solids settle rapidly and have a large sedimentation volume; peptized solids settle slowly and have a small volume. The sedimentation volume (the volume of the settled solid when it has reached the critical point) is important. Anomalous results are due chiefly to an increase in floc size caused partly by the flocs colliding and remaining adherent. The flocs are largest with slow rates of stirring. Viscosity plays a much smaller part than is generally supposed. Substances which are thixotropic give large sedimentation volumes. A.B.S.

Chemistry and Physics

Chemical analysis of gypsum. FRANCISCO J. MAFFEI. *Inst. Pesquisas Tecnológicas de São Paulo, Bol.*, No. 21, pp. 35–39 (1939); abstracted in *Chem. Zentr.*, **1939, II**, 2460.—The analysis includes water content, content in combined water, CO_2 dehydration, SiO_2 and insoluble residue, R_2O, CaO, MgO, SO_3, and chlorides. M. discusses the results of the analysis and their quantitative valuation. M.V.C.

Determining the velocity of quartzite transformations. A. M. TRAKHTENBERG. *Ogneupory*, **7** [5] 344–47 (1939).—Two methods for determining the rapidity with which quartzites transform are (1) the determination of the specific gravity of quartzite after firing in a muffle kiln, and (2) the computation of quartz grains with a strong magnifying glass. M.V.C.

Geochemistry of uranium and radium. Leaching of uranium and radium from minerals. N. M. SEGEL. *Trudy Gosudarst. Radievogo Inst.*, **4**, 350–84 (1938); abstracted in *Chem. Zentr.*, **1939, II**, 4203.—The solubility of U and Ra in torbernite and chlopinite minerals was studied. It is easier to dissolve Ra from both minerals than U. Cations accelerate dissolving in the following series: $H' > Ba'' > Pb'' > Ca'' > K' > Na'$. There is a definite proportionality between the specific surface of chlopinite and the quantity of Ra dissolved (expressed in percentages). The diffusion of Ra within the mineral is very slow. M.V.C.

Influence of sol concentration on flocculation values. E. D. FISHER AND C. H. SORUM. *Jour. Phys. Chem.*, **44**, 62–70 (1940).—Applicability of the Burton-Bishop flocculation rule to hydrosols of chromium hydroxide, stannic oxide, ferric oxide, arsenic trisulfide, manganese dioxide, aluminum hydroxide, titanium oxide, and thorium hydroxide depends on the purity of the sol. R.A.G.

Introduction to the phase rule: I–II. H. G. DEMING. *Jour. Chem. Education*, **16** [5] 215–18; [6] 260–64 (1939).—D. gives a simply worded explanation of the phase rule for beginning chemistry students. P.G.H.

Plasticity. I. F. PONOMAREV. *Keramika*, **1939**, No. 7, pp. 1–7.—P. suggests a new theory of plasticity based on the following principles: (1) the ceramic mass should be considered as a heterogeneous system; (2) under the effect of an outer stress, the plastic mass flows; (3) the plasticity of a heterogeneous system is characterized by the amount of mass in grams flowing in a unit of time over 1 sq. cm. of cross section of the stream. The plasticity of a heterogeneous system is influenced by outer stress, temperature,

composition and properties of the solid and liquid phases, and the gas phase. P.B. & E.S.

Prevention and treatment of lead poisoning. IMRE HELLER. *Orvosi Hetilap*, **83**, 639–41 (1939); *Chem. Abs.*, **33**, 8329 (1939).—In Hungarian Pb works, Pb poisoning occurs in 100 to 200 of 10,000 laborers annually. Lead accumulated within the human organism can be mobilized by modifying the Ca/P balance cautiously. This was done in clinical experiments by a diet poor in Ca and 8 to 10 gm. Na phosphate given each second day for 3 to 4 weeks. Any secondary effects of phosphate can be balanced by the administration of thiosulfate from time to time.

Silicic acid gels: IX. CHARLES B. HURD AND HARRIS W. PATON. *Jour. Phys. Chem.*, **44**, 57–62 (1940).—The effect of a change of pH on the time of set of gels produced by mixing solutions of sodium silicate and acetic acid is discussed. For Part V see *Ceram. Abs.*, **15** [3] 108 (1936). R.A.G.

Theory of light scattering. S. PARTHASARATHY. *Phil. Mag.*, **29** [193] 148–53 (1940).—P. shows that the scattering of light observed by Krishnan in binary liquid mixtures ("Molecular. . .," *Ceram. Abs.*, **17** [3] 119 (1938)) is purely molecular, while no scattering arises from clusters, if any, at the critical solution temperature. No new theories as, e.g., those of Frenkel, Gans, or Müller, appear to be necessary to explain Krishnan's results. R.H.

BOOK

Science Front, 1939. F. SHERWOOD TAYLOR. Cassell & Co., Ltd., London. Price 7s 6d. Reviewed in *Times Lit. Supp.*, **39** [1984] 79 (1940).—T. describes recent developments in science, including theoretical researches and technical inventions. Illustrated. K.W.W.B.

PATENTS

Cadmium-red manufacture. WALTER F. MEISTER (Interchemical Corp.). Can. 387,430, March 12, 1940 (June 18, 1937; in U. S. July 9, 1936). G.M.H.

Enamels and glazes and method of producing. CARL OBERLÄNDER AND F. H. ZSCHACKE (Sioto G.m.b.H.). U. S. 2,194,246, March 19, 1940 (May 20, 1936).—A preparation for improving enamels, glazes, etc., comprises a magnesium borosilicate having substantially the following composition: silicic acid 30 to 50, boric acid 10 to 30, magnesium oxide 15 to 35, and alkali compounds 10 to 20%.

Magnesium titanates and method of making. J. A. PLUNKETT AND EUGENE WAINER (Titanium Alloy Mfg. Co.). U. S. 2,196,325, April 9, 1940 (March 5, 1938).—A calcined synthetic magnesia-titania composition containing chiefly finely divided magnesium titanate chemically combined with 3 to 12% of silica and alumina, the ratio of silica to alumina ranging from 8:1 to 12:1, of particle size substantially all within the range of 0.5 to 2 microns, and having a refractive index of about 2.15.

Production of beryllium compounds. CARLO ADAMOLI (Perosa Corp.). U. S. 2,196,048, April 2, 1940 (March 20, 1937).—A process for the production of beryllium oxide from minerals containing beryllium and for the cyclic recovery of the reacting agent employed consists in powdering the beryllium-bearing ore, mixing the powder with an alkali bifluoride in an amount corresponding to 2 mols. of bifluoride for every BeO molecule present in the ore, adding water to form a paste, compressing the paste to briquettes, heating the briquettes to a temperature between 550° and 800°C. to cause the fluorine to combine with the beryllium to form a double alkali fluoride, leaching the reaction product with pure water at a temperature of about 90° to 100°C., adding alkali hydroxide to the alkali beryllium solution to precipitate beryllium as beryllium hydrate and form neutral alkali fluoride, separating the neutral alkali fluoride, calcining the beryllium hydrate to beryllium oxide, and treating the neutral alkali fluoride with a strong acid other than hydrofluoric to convert the neutral alkali fluoride to the corresponding acid fluoride.

Pure titanium dioxide. W. W. PLECHNER AND A. W. HIXSON (National Lead Co.). Can. 386,985, Feb. 20, 1940 (Oct. 12, 1937). G.M.H.

Pure titanium oxide. W. W. PLECHNER AND A. W. HIXSON (National Lead Co.). Can. 386,625, Jan. 30, 1940 (March 7, 1938). G.M.H.

Titanium pigment manufacture. ROBERT W. ANCRUM AND ASSUR G. OPPEGAARD (National Lead Co.). Can. 386,623, Jan. 30, 1940 (Nov. 29, 1937). G.M.H.

Zirconium oxide and method of making. C. J. KINZIE AND D. S. HAKE (Titanium Alloy Mfg. Co.). U. S. 2,194,426, March 19, 1940 (July 28, 1937).—A crystalline zirconium oxide obtained by the calcination of a zirconium-oxygen-carbon compound without substantial grinding of the calcined product characterized as an essentially white powder and as being essentially white in color and consisting of crystal particles having their length greater than their width and their thickness less than their width, an index of refraction of about 2.3 to 2.4, and an adsorbed colorless carbon content of about a stoichiometric equivalent of 1.64% carbon dioxide.

General

Absorption of lead and arsenic through skin. ANON. *Jour. Amer. Med. Assn., Queries & Minor Notes*, **114**, 604 (Feb. 17, 1940).—Lead and arsenic absorption through the skin does not occur to an appreciable extent in contact with aqueous solutions of these compounds in concentrations below 0.5 mgm. per 100 cc. of solution. It is unlikely that significant quantities could be ingested because of contaminated hands. F.S.M.

Clinical studies in asbestosis. M. J. STONE. *Amer. Rev. Tuberc.*, **41**, 12–21 (Jan., 1940).—This report is based upon examination of 180 persons formerly employed in the opening, carding, spinning, and weaving departments of an asbestos brake lining plant. F.S.M.

Compensation for industrial injuries and occupational diseases. E. R. KOONTZ. *Jour. Amer. Med. Assn.*, **114**, 563–69 (Feb. 17, 1940).—K. gives an excellent discussion of a few of the many legal and medicolegal phases of compensation laws of prime importance to physicians interested in the field of industrial medicine. Tables show the compensability of occupational diseases, limitations of time and cost of medical and hospital benefits in compensable injuries and diseases, and the determination of medical matters under compensation laws; all data are given by states. F.S.M.

Consider the audience. S. MARION TUCKER. *ASTM Bull.*, No. 103, pp. 27–29 (March, 1940).—T. stresses the importance of presenting papers effectively. The causes of complaints are considered. The preparation of a technical paper is taken up with regard to the content and style. The manner of presentation is also considered. The audience must be considered first in technical paper presentation. F.F.

Dust-control systems for the metal-finishing industry. RICHARD T. PAGE. *Metal Cleaning & Finishing*, **10** [8] 536–47 (1938).—Dust is undesirable in any industry. Many of the metal-finishing processes, e.g., sandblasting, grinding, buffing, polishing, etc., are outstanding dust producers. Control procedures discussed are (1) personal respiratory protection, (2) substitution of a less harmful material causing the dust, (3) wet methods, (4) complete enclosure of the dusty process, (5) segregation of part of the equipment, (6) improved ventilation, (7) partial enclosure under negative pressure, and (8) local exhaust ventilation. A detailed study of dust-collection systems is presented. Air motion is discussed, and a table of air speeds in ducts necessary to convey various materials is given. A table shows the minimum thickness of metal for straight exhaust piping. Fans and cleaning apparatus

for dust control are described. Bibliography and four figures. F.F.

Hematological changes in cadmium poisoning. A. BRIGANTI. *Folia Med.*, **25**, 1108–15 (1939); (in Italian).—Animal experimentation shows that cadmium injures the blood marrow and causes hypoglobulia, leucopenia, granulocytopenia, and thrombocytopenia. F.S.M.

Hematological changes in selenium poisoning. A. VESCE. *Folia Med.*, **25**, 1014–25 (1939); (in Italian).—V. presents a survey of industries employing selenium and a description of the chemical symptoms of the poisoning. In his animal experiments he found secondary anemia as a direct effect on the blood cells. F.S.M.

Hygienic significance of the effect of air douches for the improvement of working conditions in hot work places. W. LIESE. *Z. Hyg. Infektionskrankh.*, **122**, 24–40 (1939).—Men exposed to high temperatures and much radiant heat, especially in the tin-plate and glass industries, have been able to reduce discomfort by directing a stream of air over their bodies. L. describes the effects of these air streams, judging their influence by the forehead temperature of glassworkers. Curves are given to show the effect of radiant heat in raising the forehead temperature and of the air douche in reducing it. The velocity of the air stream should not be too high; between 200 and 400 ft. per min. is suitable. The temperature of the stream should not be much cooler than the surrounding air. F.S.M.

Industrial medicine. W. I. CLARK. *New England Jour. Med.*, **221**, 269 (1939).—C. discusses present views on pneumoconiosis and gives an interesting outline of cancer of industrial origin. Heat cramps and the toxicology of various vapors, dusts, and gases are noted, and the usefulness of the Massachusetts list of permissible concentrations of various substances in air is pointed out. An important need in surgery is an intelligent view on the problem of rehabilitation. See *Ceram. Abs.*, **18** [8] 225 (1939). F.S.M.

Injurious effect of inhaled aluminum dust. O. EHRISMANN. *Z. Hyg. Infektionskrankh.*, **122**, 166–70 (1939).—E. was unable to find injury in the upper or lower respiratory tract in animal experiments made some years before. F.S.M.

Gordon C. Keith. ANON. *Bull. Amer. Ceram. Soc.*, **19** [4] 153–54 (1940).

Pneumoconiosis and pulmonary syphilis. I. RAUCOUCHOT AND A. LUGAND. *Bull. Soc. franç. Dermatol. et Syphil., 46th Meeting*, pp. 611–13 (1939).—The X ray of a worker who was exposed to very large amounts of organic dust (in an insecticide factory) and who always wore a respirator showed an intensified shadow of the hilus and increased fibrosis in the inferior lobes. It was at first thought to be early pneumoconiosis but was later diagnosed as pulmonary syphilis. F.S.M.

Recent Commission findings. ANON. *Ohio Industrial Commission Monitor*, **13**, 25–26 (Feb., 1940).—At an original hearing wherein the widow of a pottery worker had applied for a death award, alleging that the death of her husband had been due to silicosis, a compensable occupational disease, medical proof of the presence of silicosis was lacking, although the decedent had worked for 19 years in a potentially injurious dust exposure. An autopsy examination was made. Basing their conclusion upon the autopsy report, the Silicosis Referees reported that complete evidence was found that the deceased had been suffering from silicosis, complicated by extensive bilateral tuberculous pleurisy and tuberculous peritonitis which were the cause of his death. The Commission allowed the claim and the widow received $850, which is the maximum possible under the Silicosis Act for this particular case. F.S.M.

Silicosis. ANON. *Ceram. Ind.*, **34** [4] 41–42, 63–66, 68, 70, 72, 74, 76, 78 (1940).—Results of medical investigations and a discussion of harmful reactions are included in the first section of this survey, together with a description of the development of the disease, ways of retarding it, and its diagnosis. Typical examples in the ceramic industry in which there may be some possibility of the occurrence of silicosis are considered, as well as the possibility of its exploitation by unscrupulous lawyers. In the second section, recent improvements in dust sampling and counting equipment and methods of taking accurate dust counts are dealt with. Necessity of employee cooperation in a dust-prevention program is emphasized. The third section concerns ways of removing dust and the action which some plants have taken. The following methods are listed: (1) segregation of the dust-producing operation, (2) substitution of dustless producing methods and material as far as possible, (3) wetting of the dust at its source, (4) use of personal respiratory protective devices, and (5) installation of adequate exhaust systems. Principles of exhaust-system design are considered, and types of dust collectors are listed. Separate sections are devoted to pottery, glass, and enamel plant operations and dust control. Illustrated. L.M.C.

Silicosis in gold miners of Bellière in Maine-et-Loire. R. AMSLER AND J. CADY. *Rev. de tuberc.*, **5**, 580–91 (1939).—The authors describe cases of each type of silicosis and discuss the terminal stage with its complications, such as spontaneous pneumothorax. They also take up the concurrence of silicosis and tuberculosis; the lesions of gold, iron, and slate miners present such characteristic modifications that it may be possible to identify these workers on the basis of the roentgenographic aspect of their thorax. F.S.M.

Silicosis and tuberculosis roentgenologically simulating a neoplasm. E. A. POHLE AND G. RITCHIE. *Amer. Jour. Roentgenol. & Radium Therapy*, **43**, 42–44 (Jan., 1940).—Silicosis usually produces a fairly typical picture in the X ray, and the differential diagnosis can be made from the history of exposures to dust. In this case the roentgen findings were suggestive of neoplasm, while the autopsy revealed only hilar silicosis and tuberculosis. There was no history of exposure to dust containing silica, and the lesions were distributed in an extremely unusual manner for silicosis. The extreme dyspnea was caused, the authors feel, by the contraction of the hilar scar tissue about the main bronchial trunks. F.S.M.

To stop silicosis. S. C. BLACKTIN. *Chem. Age* [London], **42** [1077] 97–99 (1940).—With ordinary methods of dust filtration, the filter gradually becomes clogged and useless in spite of cleaning devices. B. describes a device which is free from this objection. In it the dust particles are repelled by the diaphragm while the air particles pass through it; consequently, there is no obstruction of the diaphragm. The diaphragm consists of a cylinder of metallic gauze of suitable mesh heated (electrically or otherwise) to a suitable temperature. In coal mines where electric safety lamps are used, these can provide the heat required for the gauze. The cleaned air can be cooled by contact with the metallic surfaces of the lamp. The resistance to breathing is much less than in any other form of respirator and it does not increase with use. A.B.S.

BOOK AND SEPARATE PUBLICATIONS

Bibliography of Industrial Hygiene: Vol. 13, No. 3. International Labor Office, Geneva, Sept., 1939. 58 pp. Price 40¢.—Printed in French, English, and German, this publication contains a large number of references to the general subject of industrial hygiene and medicine. It is evidently brought up to about the middle of the summer of 1939. It has been published quarterly heretofore, but publication is suspended until further notice. Copies may be obtained from the Branch Office at 734 Jackson Place, Washington, D. C. F.S.M.

Guide to Workmen's Compensation: The Law and Its Practice in New York State. H. D. MARGULIES AND MAX BLOOM. Progress Books, New York, 1939. 96 pp. Price, paper, 50¢.—The New York Workmen's Compensation Act is stated in simple terms for the workman, trade unions, attorneys, and physicians, based on court decisions and publications of the Labor Department of New York. Sixteen rules for physicians promulgated by the State Industrial Commission are included. F.S.M.

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